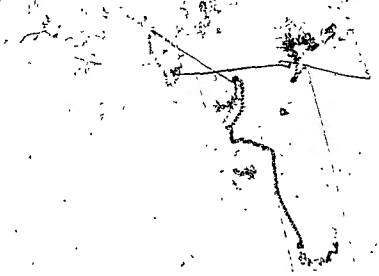
Water Powers of Canada

The
Prairie Provinces

Manitoba
Saskatchewan
Alberta

By Percival H. Mitchell



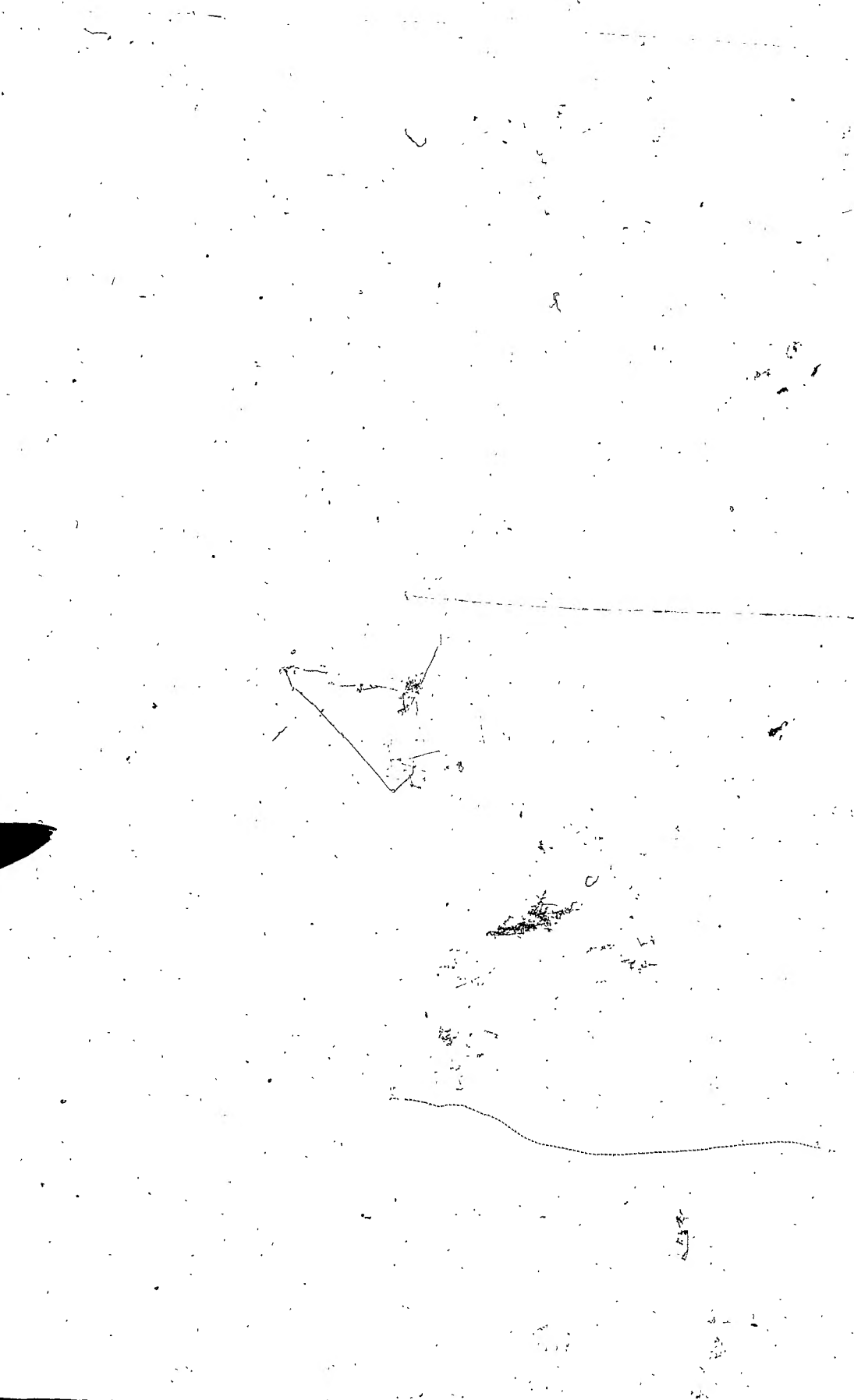
Department of the Interior, Canada.

HONOURABLE W. J. ROCHE, MINISTER.

W. W. CORY, C. M.G. DEPUTY MINISTER.

Water Power Branch

J. B. CHALLIES, SUPERINTENDENT



"An examination of any good map of our broad Dominion, reveals, as its most striking feature, an extraordinary wealthy and remarkably uninterrupted succession of lakes and rivers, suggestive of ample rainfall, the first great requisite in the occupation of any country. Over a length of several thousand miles, between Labrador and Alaska, and over a width of several hundred miles, there is an almost continuous distribution of lakes; lakelets and rivers; the lakes of varied outlines, dimensions and elevations above sea level, and many possessing facilities for the storage of their flood waters. In many places the outlet from the lake or the connection between a chain of lakes is a narrow cleft in rock where an inexpensive dam will hold back the water supplied by the winter's accumulation of snow."

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From a Presidential address on the Water Powers of Canada before the Royal Society of Canada, in 1898-99, by the late T. C. Keefer, C.E. C.M.G., Honorary Member of the Institute, American Society and Canadian Society, of Civil Engineers; Past President of the American and Canadian Societies of Civil Engineers.

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Dominion Water Power Branch
Department of the Interior
Ottawa, Canada

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THIS little book on the Water Powers of the Provinces of Manitoba, Saskatchewan and Alberta, "The Prairies Provinces," published by direction of the Honorable W. J. Roche, Minister of the Interior, Canada, was written by P. H. Mitchell, E.E., Associate Member Canadian Society of Civil Engineers, Associate Member American Institution of Electrical Engineers, Member American Society of Mechanical Engineers, at the request of the Superintendent of the Dominion Water Power Branch, for distribution in connection with the water power exhibit of the Dominion Government in the Canadian Building at the Panama-Pacific Exposition.

This water power exhibit was prepared by the Dominion Water Power Branch under the direction of the Commissioner General of Canadian Exhibitions, with the object of showing visitors to the Exposition the tremendous water power resources of Canada, and especially the great progress already made in the art of power development and use throughout the Dominion.

The outstanding feature of the water power situation in Canada, is the fact that practically all industrial and commercial centres in the Dominion, from coast to coast, have sufficient potential water power within easy transmission radius and of sufficient capacity and assured economic feasibility of development to meet all anticipated requirements for the future.

INTRODUCTION

THE Dominion of Canada has been most liberally endowed with a richness of natural resources possibly unrivalled in any country of the globe. The wealth of the land, the forest and the mine, has a world-wide reputation; the neighboring oceans, the lakes and the streams, for their transportation routes, their fisheries and their water powers are equally well known. The commerce and industry created by such a fund of resources has as one of its greatest elements of success the proximity of water powers to the power consuming market.

Electricity, as the intermediary between the power of the water fall and the power available at the consumers machinery, has been the great stimulus to water power development and to the rapid progress in manufacturing industry. The capability of generation in large units converting the mechanical power of the water turbines to electrical energy, the economical possibilities in transmission and distribution, and the multitude of its applications, establishes electricity as the foremost power medium.

While the source of electric power for commercial purposes is motive power produced by steam, oil, gas or water, in Canada it is notable that without exception all cities are now supplied by or are within the economic distribution zone of hydro-electric sources, and further, commercial conditions are such that power from these sources is available to the consumer at very attractive rates and it is apparent that the future of power consuming industries has its foundation in the bountiful and widespread water power resources of the country.

The Dominion of Canada has an area of 3,745,574 square miles, stretching from the Atlantic to the Pacific, and from the Northern boundary of the United States to the Arctic Ocean.

The Northwest Territories, the vast Northern portion of Quebec and the greater part of the Yukon cannot be considered, within our generation, to be factors in the industrial field. The possibilities from the standpoint of natural resources are not as yet, with the incomplete investigations up to the present, capable of appreciation; water power is plentiful but so remote from any present market that the capacities of the thousands of known water powers are not included in statistics; within a limited area the Yukon is an exception. In the provinces of Nova Scotia, New Brunswick, Prince Edward Island, Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia, power is available in great abundance.

Within the provinces of the Dominion of Canada and excluding the Northwest Territories, practically all of the Yukon, and the Northern and Eastern portion of Quebec, it is estimated that 17,764,000 h.-p. is available, this amount being inclusive, in the case of Niagara Falls, Fort Frances and the St. Mary's River at Sault Ste. Marie, of only the development permitted by International treaties, and further does not contemplate the full possibilities of storage for the improvement of capacities. The developed powers which are inclusive of all water powers whether for electrical production, pulp grinders, for milling or for the great many other uses, aggregate 1,711,188 h.-p.

This pamphlet deals especially with the water powers of the Provinces of Manitoba, Saskatchewan and Alberta, the Prairie Provinces, and as naturally required in a consideration of this subject, include the necessarily brief mention of the water powers of the Northwest Territories and the Yukon.

The Prairie Provinces are essentially agricultural. Red Fife and Marquis are names to be conjured with in the wheat markets of the World. The deep rich prairie soil is a mine available to hundreds of thousands of farmers whose dividend of golden grain is never failing. The settlement of the great west has been fabulously rapid and the industrial development has far from kept pace with the agricultural requirements; the industrial era has, however, dawned, and it is to be expected that in the near future the local consuming market will be to a great extent satisfied by local manufacturers.

The several millions of horse-power available within the economic zone of transmission in these Provinces, and the 100,000 h.-p. now developed for the population of 1,500,000, are conditions indicative of the future demand and future possibilities of water power.

The uses of electric power in an agricultural country are threefold: first, directly applied to the production, operation and marketing of the products and natural resources; second, for manufacturing purposes in the supplying of the market created by the people of such a country; and third, in the community life, the public utilities and transportation.

It is not hard to predict the future of electric power under such conditions. The enormous strides of the past twenty years, in reality the period since the establishment of the first commercial electrical transmission system, has developed established loads necessitating in United States and Canada, alone, the development of water power plants aggregating nearly ten million horse-power, the last ten years more than doubling the first ten years in the rate of growth. With the tremendous industrial progress now under way is it not fair to say that the power demand will be doubled again in the next ten years? The load curves showing the growth in power requirements from year to year in each of the large cities of Canada show an increase from very small dimensions of from five to ten years ago to enormous demands, and at a rate of doubling in from one to three years, and with the curve of the load diagram indicating most vigorously similar increases in the years to come. While it is quite apparent that the greatest portion of these loads is consumed in the older districts in the Great West, the population and the quantity of output is, too, increasing very rapidly, adding a new factor of growth to the swelling power demand the combined effect of which is readily borne out by the evidence of the respective records.

The water powers of Manitoba, Saskatchewan, Alberta, the Northwest Territories and the Yukon are under control of the Dominion Government. The Dominion Government water power policy, as administered by the Water Power Branch of the Department of the Interior, affords every reasonable protection to the public as to rentals, periodic revisions, control of rates, limited grants, etc., and at the same time fosters legitimate private enterprise to return reasonable profits. Regulations are in force affording all possible assistance to the development of water powers which have every reasonable assurance of economic utilization, and further, before the authorization to proceed with developments is given, complete investigations are undertaken to prove the economic features of design, capacities and costs, and eventually supervision is carried out during construction. Proper government supervision and control of the construction and maintenance of all developments is

the only safe method of intelligently initiating construction and maintaining an adequate system of river improvement for power purposes.

In the consideration of the water powers of Manitoba, Saskatchewan and Alberta, two river systems stand out pre-eminently, that of the Winnipeg River in Manitoba and the Bow in Alberta. The rapidly increasing utilization of these rivers for power purposes, the power plants at present contemplated for construction, and the value of the potential water powers not yet awarded, has required the immediate attention of the Dominion Government as to the possibilities in each case, and these demands have resulted in exhaustive investigations. The complete reports in these two instances have been embodied into the "Water Resources Papers" of the Water Power Branch of the Department of the Interior under the title of "Bow River Power and Storage Investigations" and "Manitoba Water Powers," respectively. Pages 17 to 45 following, are in general compiled from these two reports, and the reports themselves should be referred to for more complete information as to the method of individual and general development, storage, detailed costs and possible market.

Pages 45 to 59 consider the water powers of these Provinces and the Northland by dealing with the powers on the respective main rivers and drainage systems, most of the water powers included thereunder having been the subjects of reports by the Dominion Water Power Branch.

WATER POWERS OF THE PRAIRIE PROVINCES

ANY consideration of the power situation of a country must present the features, physical, historical, commercial and social, which respectively affect the utilization of power. This is essentially so in this particular instance, as the future of the Prairie Provinces is so dependent upon the individual, natural and acquired characteristics of the country.

The Prairie proper, that is the naturally treeless section, has a roughly triangular shape, with an area twice that of Great Britain. The eastern boundary is the forest covered rugged granite Archean hills; the southern base of about 800 miles is the international boundary between Canada and the United States, and north and west the plain is circumscribed by the lakes of Manitoba, the bluffs north of the Saskatchewan, and on the west and northwest by the Rockies and by the foothills.

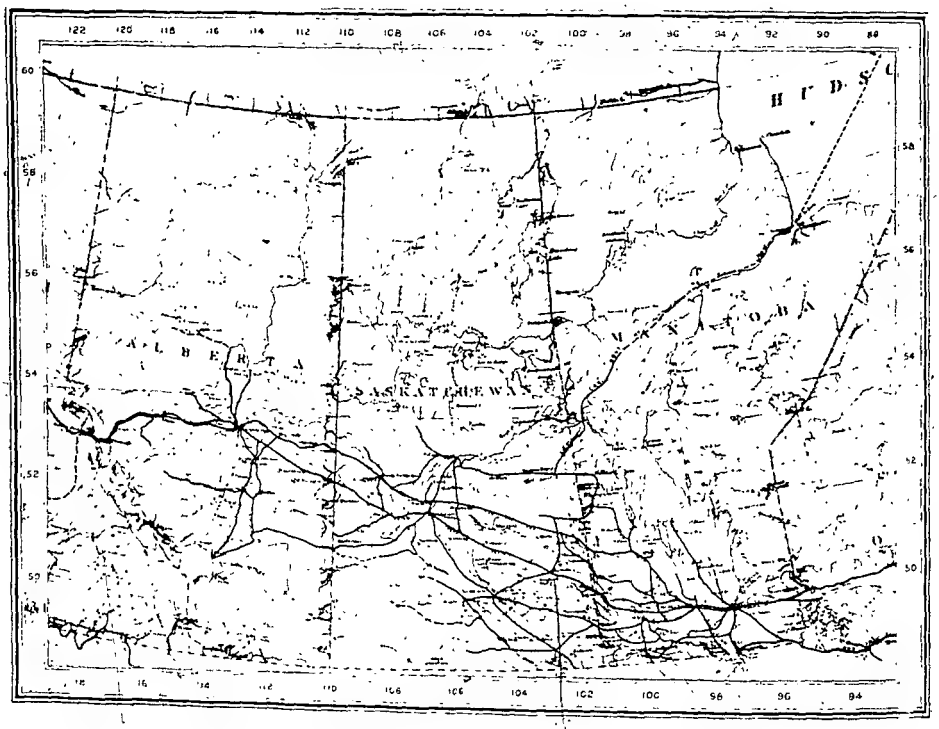
Lake Winnipeg, Lake Manitoba and Lake Winnipegosis, comprise the largest bodies of water in the Provinces, and are the natural collecting basins for an area of 403,000 square miles. Lake Winnipeg itself has an area in excess of Lake Ontario, and into this great lake flow the waters of the Winnipeg, the Red and the Saskatchewan Rivers, besides the innumerable local rivers, and then by the outlet, the Nelson River, the lake waters are carried to Hudson Bay. The river system of the Saskatchewan, with its two branches, the North and the South Saskatchewan, traverses the Provinces from west to east, both branches rising in the Rocky Mountains.

The northern part of Manitoba is drained by the Churchill River. The northern parts of Saskatchewan and Alberta are drained through the Athabaska and Peace Rivers, first northeastwards towards Athabaska Lake, then north through Slave River to Great Slave Lake, and finally north-west through the MacKenzie River to the Arctic Ocean.

The prairie plain is the present indication of the ancient sea of which it was the bed in Mesozoic times. Most of the plains are underlain by cretaceous and early tertiary shales and sandstones lying nearly unaltered and undisturbed where they were deposited, although now raised far above sea level, particularly along the border of the Rocky Mountains where they were thrust up into foothills when the range itself was raised. Though the region is spoken of as a plain, there are really great differences in level between the highest parts in south-western Alberta, 4,500 feet above the sea, and the lowest in the region of Lake Winnipeg where the prairie is at an elevation of only 800 feet. The very flat and rich prairie, near Winnipeg, is the former bed of the ancient glacial "Lake Agassiz"; most of the prairie to the West, however, is of a gently rolling character, and there are two rather abrupt breaks in the plain, the first step representing a rise to 1,600 feet and the second to 3,000 feet on an average.

The Rocky Mountains are the western boundary of the three Provinces. These mountains are the most recently formed of the Cordilleran belt, which includes also the Coast ranges, the Selkirks, the Gold Ranges and the Caribou Mountains, all the latter being in the adjoining Province of British Columbia, between the Rockies and the Pacific. The

Rockies were formed by tremendous thrusts from the Pacific side, crumpling and folding the ancient sedimentary rocks which run from the Cambrian to the Cretaceous periods and faulting them along overturned folds. The outer ranges in Alberta have usually the form of tilted blocks with a steep cliff towards the north-east, and a gentler slope, corresponding to the dip of the beds, towards the southwest. Near the centre of the range there are broader foldings, carved into castle and cathedral shapes. The most easterly range has been shown to have been actually pushed seven miles out upon the prairies.

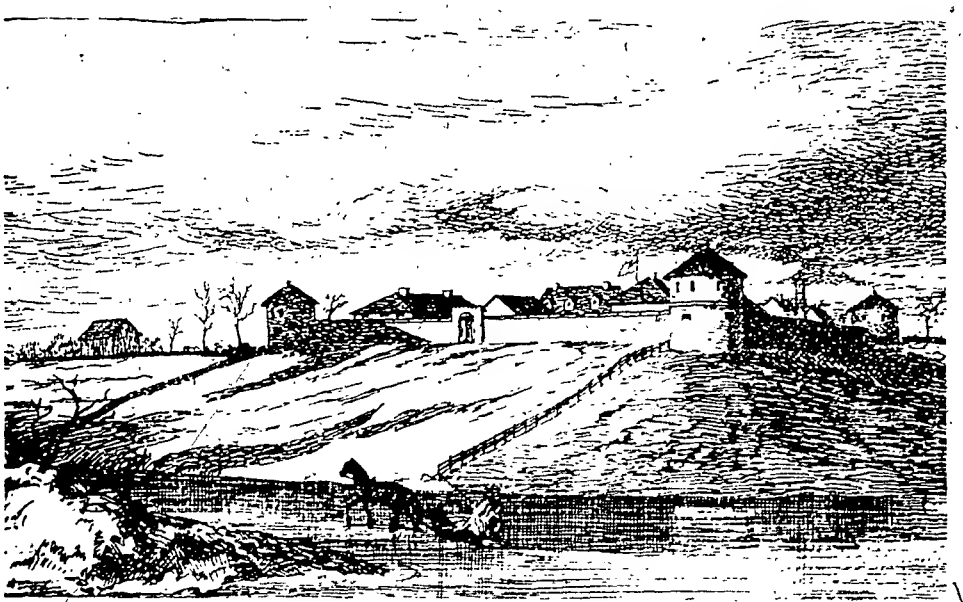


Manitoba, Saskatchewan and Alberta, Canada. "The Prairie Provinces."

The Prairie Provinces have in most parts a distinctly continental climate, with comparatively short warm summers and long winters, but with much sunshine in both seasons. In Southern Alberta, however, the winter cold is often interrupted by chinooks, westerly winds which have lost their moisture by crossing the mountains and become warmed by plunging down to the plains where they blow strongly, absorbing every vestige of snow and raising the temperature sometimes in a few hours from 20 to 40 degrees. The precipitation in Manitoba has a mean of about 17.5 inches, while Saskatchewan and Alberta have a precipitation of about 13.5 inches; the greater portion of these amounts occuring from May to August.

The early history of the West is wrapped up in the exploits and rivalry of the French and English traders. In 1659 the first French explorers emerged upon the prairies after traversing the great lakes and the further river routes, and long after, in 1743, later French adventurers came across the plains into the Rockies. In the intervening period and later, the French Company, whose charter from France embraced the whole of Canada, established the foundation of their fur trading system. In 1670 Charles II. granted a charter to Prince Rupert and his associates, incorporating them as the "Governor and Company of Adventurers of England trading into Hudson Bay". To-day the Hudson Bay Company is very active maintaining its ancient posts throughout the great northland, and in the towns and cities establishing stores, some of immense proportions, in which a most intensely modern business is carried on. In the early career of the Hudson Bay Company the losses were enormous, consequent upon the raids and military expeditions against their forts by the French, and later, when Canada was ceded to Great Britain, the many independent traders who were gradually encroaching on the Company's domains formed the North-West Fur Company, and with this acquired strength began a most bitter rivalry, only ended in 1821, when the two factions, mutually exhausted and with the Indian trappers demoralized, amalgamated. The old forts in the far north, still actively operated and still in their prime, are the centres of the present remote communities.

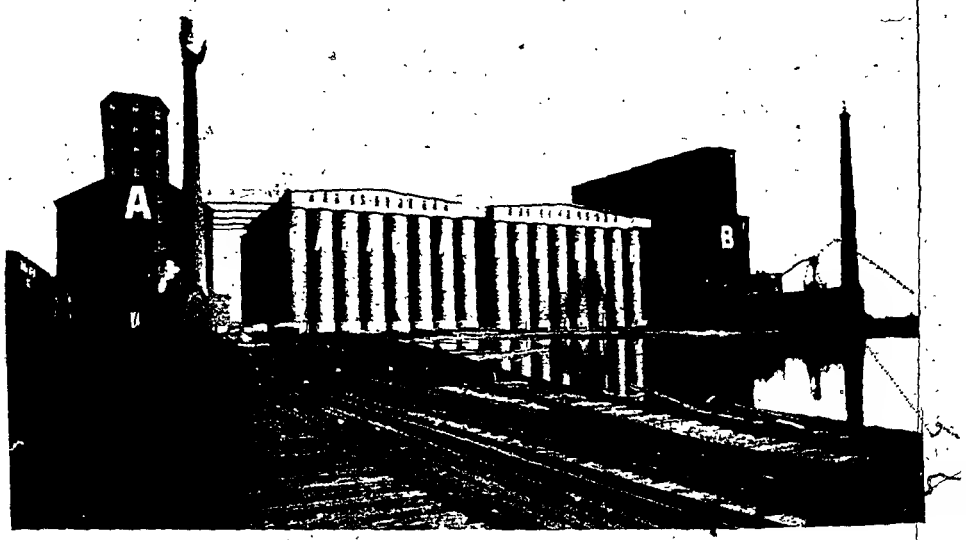
The plains and the forests were the hunting grounds of the Indians; the falls, the rapids and the portages, the old highways of the past, recall wonderful stories of the primeval days when the civilization of the fur traders was unknown, when the buffalo in their herds



Fort Garry (Now Winnipeg), Red River Settlement, 1852.

of millions roamed the prairies. Manito-waba, the Voice of Manitou, calling from Lake Winnipeg's Narrows, took the Indians northward and up the broad Saskatchewan, the "rapid river" of the Crees, across the rolling prairie to the great foothills. The prairies then knew no tilling, the rank grass stretched to the wide horizon, and many a broad expanse had no sight of man until the Red River ox-cart and the prairie schooner wended their way with the hardy pioneers of fifty years ago.

As the confederation of the Provinces proceeded in the latter half of the past century the wealth of the Prairies was fully recognized, and one of the first steps was the construction



A 10,000,000 Bushel Elevator for Western Wheat

of a transcontinental railway, the Canadian Pacific, through to British Columbia and the Pacific Ocean. With this great boon the settlers, who formerly made the tedious journey down the Red River from St. Paul in the United States, rapidly flowed into the land offered free by the Dominion Government, or which was to be acquired for next to nothing. The towns like Winnipeg, a City now of 242,000 population, and which in 1874 had but 1,8 inhabitants, sprang up quickly, and the other large cities of Portage La Prairie, Brandon, Regina, Moose Jaw, Saskatoon, Prince Albert, Medicine Hat, Lethbridge, Calgary and Edmonton quickly demonstrated their permanency, and now are the centres of great wealth

To-day three great Canadian transcontinental railways traverse the whole Dominion and weave a network through the Western Provinces, bringing each farming and industrial district within the range of transportation facilities. The Canadian Pacific Railway, the Grand Trunk Pacific and the Canadian Northern Railway, with their lines throughout

Dominion, have over 35,000 miles of track, the traffic of wheat and grain moving eastward and manufactured products moving westward. As new Western districts prove themselves, the arteries of the railroads move onward and as the agriculturist moves farther north and northwest, overcoming nature's obstacles as he progresses, the steady expansion takes place until it makes us gasp to think of the developments of a generation hence, when new fields and new possibilities of this Canadian West, unthought of now, will become the commonplace realities, and still further afield will be new lands to conquer.

The wealth of the agriculturist of the West lies in wheat, the climatic conditions combining with a richness of soil to produce a quality unexcelled in the World. Year after year in the authorative International contests Canadian grown Marquis wheat, one of the most recent of the special grain developments of the scientist for Canada's Western Provinces, has carried off the honours and thus proclaimed to the World the reasons for premium prices and established markets. Live stock, softer grains and mixed farming, form the secondary sources of wealth, and to-day the natural resources are being laid bare and being developed into a renumerative field of greatest prominence.

WATER POWER ON THE WINNIPEG RIVER

THE Winnipeg River is notably one of the most important power rivers on the Continent, draining as it does an area of some 55,000 square miles into Lake Winnipeg. This great watershed comprises the Rainy Lake and Lake of the Woods and the English River, all inclusive of the immense circular area about 250 miles in diameter, lying immediately north-west of Lake Superior. The myriad of lakes, varying from miniature pools to the 1,500 square miles of area of Lake of the Woods, the summer time playground of the middle West; the vast expanse of muskeg and marsh; the veining of interconnecting streams; the swelling rivers for ever accumulating their waters, all contribute to the great Winnipeg River, and tumbling down its ceaseless falls and rapids the waters flow tranquilly into the broad Lake Winnipeg, resting a while, then mingling with the rivers from the Rockies and from the Prairies, to go rushing down the mighty Nelson River to Hudson Bay, the sea, at last.

While the watershed of the Winnipeg River lies for the most part in the adjoining Province of Ontario and across the boundary in the United States, the power possibilities of greater magnitude are included in the Province of Manitoba. From the Provincial boundary line to Lake Winnipeg, the Winnipeg River has a fall of 273 feet, the head waters of this portion of the river being at an elevation of 983 feet above the sea level, while Lake Winnipeg is 710 feet above the sea level. Lake of the Woods is at an elevation of 1,060 feet, so that the fall to the Provincial boundary is 77 feet. The fall of 710 feet from Lake Winnipeg to the sea level in Hudson Bay, combined with the immense flows from the tributary watersheds indicates the enormous potential water powers on the Nelson River; this will be dealt with in a succeeding chapter.

The lakes, rivers and muskegs of the head waters provide notably practical opportunities for storage. It must be realized that the climatic conditions prevailing in the northern

part of the temperate zone in America, combine to create a condition of water run-off varying considerably from the seasonable flows of farther south. The decreased rainfall and increased evaporation of late summer, similarly as with southerly climates, creates a period of low river flow in August and September. In winter, however, the natural storage areas are sealed with ice, the drainage arteries freeze, the surface ice of the lake depletes the available water, and all these sources failing or diminishing, low water flow, appreciably less than the minimum summer flow, results. On the Winnipeg River this condition is particularly noticeable.

On the Winnipeg River

From observation extending over many years, and from accurate daily records kept for the last eight years, the flow of the Winnipeg River has been studied under varying conditions. During this latter period a maximum flow of 53,400 cubic feet of water per second has been recorded, while the minimum flow has been found to be 11,700 cubic feet per second. The high water marks along the shores would indicate that floods of 100,000 second feet have occurred in the past; such floods, however, must take place at very rare intervals. The yearly average flow over this same period has varied from 19,000 to 34,000 cubic feet per second.

The commercial value of the numerous water powers of the Winnipeg River are fully appreciated. The proximity to the City of Winnipeg, at the gateway to the Great West whose growth, in population, in wealth, in industry and in commerce, has been amazingly beyond the most optimistic predictions, has in itself provided a market of great magnitude now being served by two developed falls of this river. The rapid increase in power consumption has already exhausted the capacity of one power development, and has necessitated the other continually installing additional machinery, much in excess of the limit

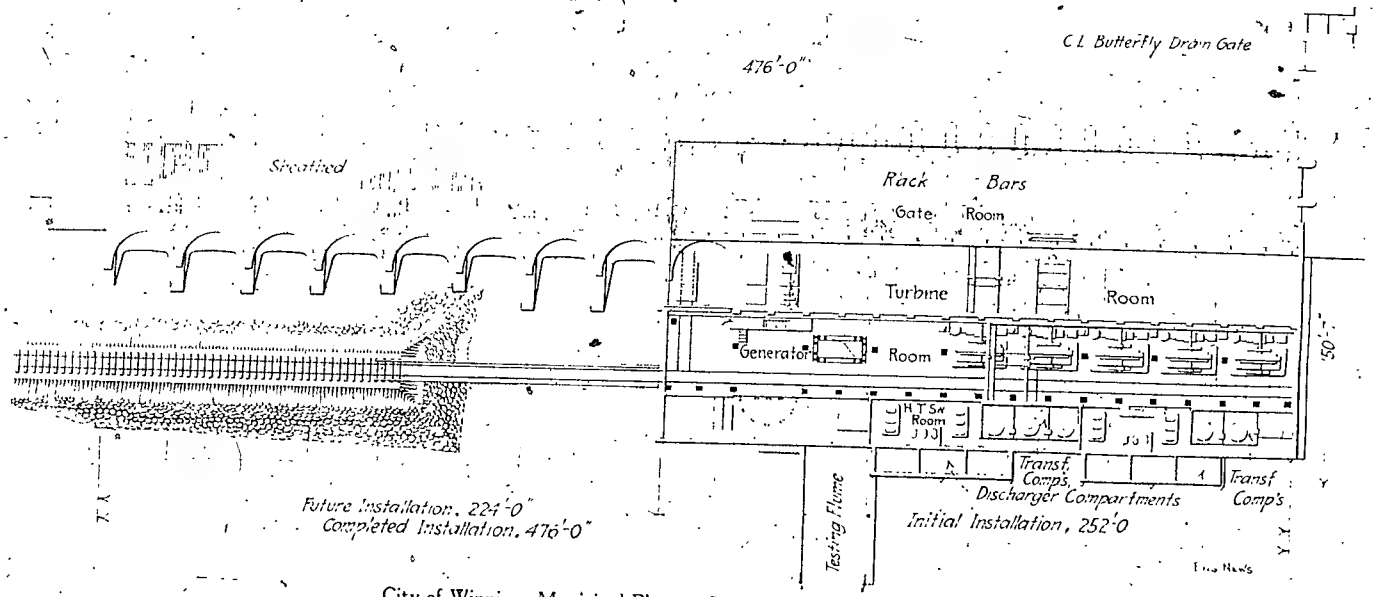
capacity originally contemplated. That the possible extent of market of the immediate future is fully anticipated by the keenest of power developing interests is most positively indicated by the fact that the Water Power Branch of the Department of the Interior of the Dominion Government has received numerous applications from capable and sound sources for the various undeveloped water powers; many of these overlap, many contemplate the combination of several successive falls by the concentration of their respective drops at one power site, and several are for individual falls.

The application for the respective power sites on the Winnipeg River are so varied and are so conflicting, while at the same time supported by such reputable engineering advice that the Government found it inadvisable to commit itself, with respect to any future developments on the river, until from an exhaustive survey and investigation could be constructed, a proper basis of consideration which would determine the maximum possible advantageous utilization of the water power resources. This river study has advanced to the final stages and the full possibilities can only now be fully recognized.

After several years of work, by the Government's Engineers, the various power sites have been established; the proper combination of the smaller falls selected to conform to the most economic development; the most feasible scheme of utilization planned, and the general design proceeded with sufficiently, to determine constructional costs on a reliable basis, and from these, the yearly cost of power deduced.

The Department is therefore in a position to dictate a policy of power development which will ensure the full and maximum utilization of the river resources. The investigations and

Winnipeg River. Point du Bois Falls. Showing Dam of City of Winnipeg Power Plant in distance.



City of Winnipeg Municipal Plant,—Sectional plan of Power House.

conclusions have been compiled into a report to be issued by the Dominion Water Power Branch, as "Water Resources Paper No. 3."

The Winnipeg River power sites are concisely shown in the following, and the more detailed features discussed in the same order:—

UNDEVELOPED POWER SITES ON THE WINNIPEG RIVER IN MANITOBA

Site	Distance from Winnipeg in miles	Head	POWER AVAILABLE			
			24 hour power at 75% efficiency		Turbine Installation (Units considered)	
			12,000 sec. ft.	20,000 sec. ft.	12,000 sec. ft.	20,000 sec. ft.
Pine Falls	64	37	37,900	63,100	6–10,000	10–10,000
Du Bonnet Falls	64	56	57,300	95,500	9–10,000	14–10,000
McArthur Falls	62	18	18,400	37,000	11– 2,500	17– 2,500
*Lower Seven Sisters	52	37	12,600	37,900	. . . . .	6–10,000
*Upper " "	55	29	9,900	29,600	. . . . .	8– 6,000
Slave Falls	74	26	26,600	44,400	8– 5,000	13– 5,000
Total			162,700	301,200	217,500	555,500

NOTE.—*The Upper and Lower Seven Sisters sites are located in the main channel of the Winnipeg River, paralleling the Pinawa, through which 8,000 second feet are assumed to be diverted for the operation of the Winnipeg Electric Railway Company's plant.

It will be noted that the Winnipeg Municipal Plant and the Winnipeg Electric Railway Company's plant are developed and aggregate a turbine capacity of 79,700 h.-p. Further it will be noted that capacities of all sites are given for flow of both 12,000 and 20,000 cubic feet of water per second, as representing respectively present conditions and future conditions after storage is established.

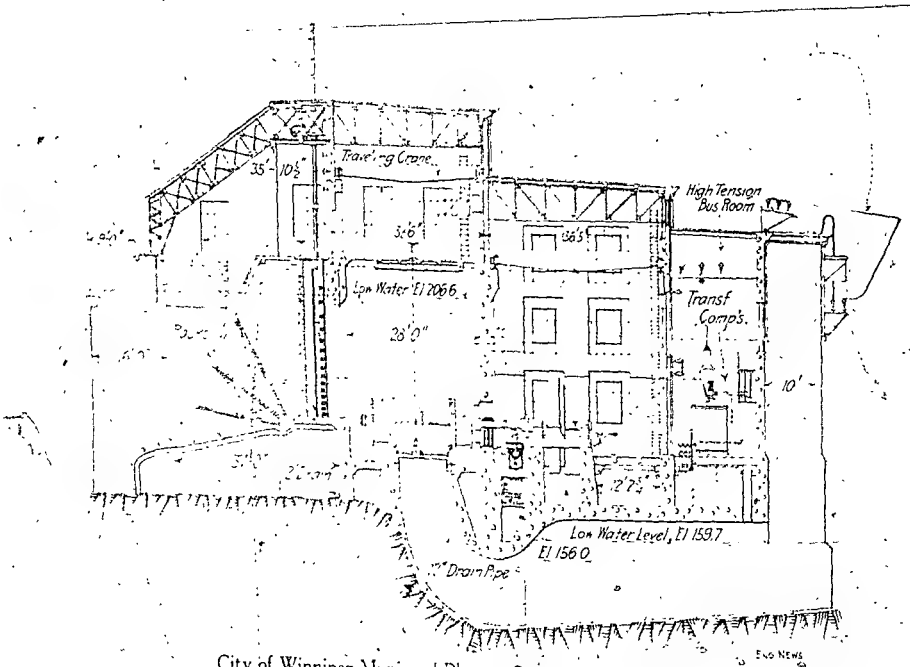
The City of Winnipeg hydro-electric development at Point du Bois, 77 miles from the City of Winnipeg, is the first power site to be considered when coming down the river from the Provincial boundary. In 1905 the enthusiastic and progressive citizens of this western City launched this cheap power project, and following a reconnaissance study of the various sites, the Point du Bois Falls were chosen as the most favourable, considering cost, facilities for development works and the necessary magnitude, to conform to the expectations of the future load. Designs were proceeded with, a railway built to the City from the terminus of the Canadian Pacific Railway at Lac du Bonnet to Point du Bois, a distance of 22 miles, and later the contracts were let for the construction of the necessary works. Here was

accumulated power producing machinery and equipment from world wide sources, and eventually the plant was completed for the initial capacity; the transmission line, 77 miles of steel towers, to Winnipeg was constructed, and the era of cheap power was inaugurated.

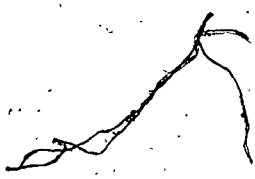
The Point du Bois plant, will have an ultimate capacity of 76,000 h.-p., when operating on a regulated flow of 20,000 cubic feet of water per second and at the normal hydraulic head of 45 feet. The present installation consists of five turbines of 5,200 h.-p. capacity each, and three turbines of 8,500 h.-p. capacity, aggregating 51,500 h.-p., installed in addition to turbine operated exciter generators which magnetize the power generators direct connected to the large turbines. The ultimate installed capacity will be 119,500 h.-p., the whole of which may be utilized on 20,000 cubic feet per second flow, by using the available pondage in the river immediately above the dam. The electric power produced by the turbines and generators is stepped up to 66,000 volts for transmission over the aluminum cables to Winnipeg, where it is stepped down again for distribution throughout the City.

The Winnipeg River is dammed across at the head of the falls, and a canal has been cut through the solid rock, leading the water to a forebay immediately adjoining the power house.

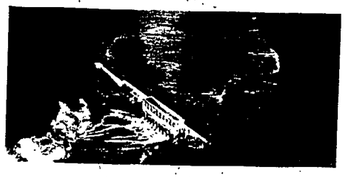
The several illustrations shown in these pages will serve to show the general scheme of development. Reproduction on page 24 shows a photograph of the power house and lower works from the downstream side, and a cross section of the generating station is shown below



City of Winnipeg Municipal Plant.—Section through Power House.



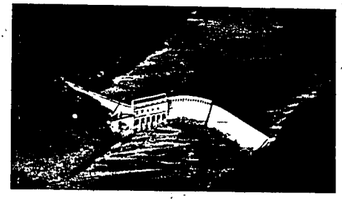
AEROPLANE VIEW OF SOUTH-EASTERN MANITOBA



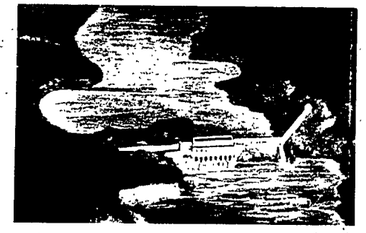
Pine Falls.

Du Bonnet Falls.

McArthur Falls.

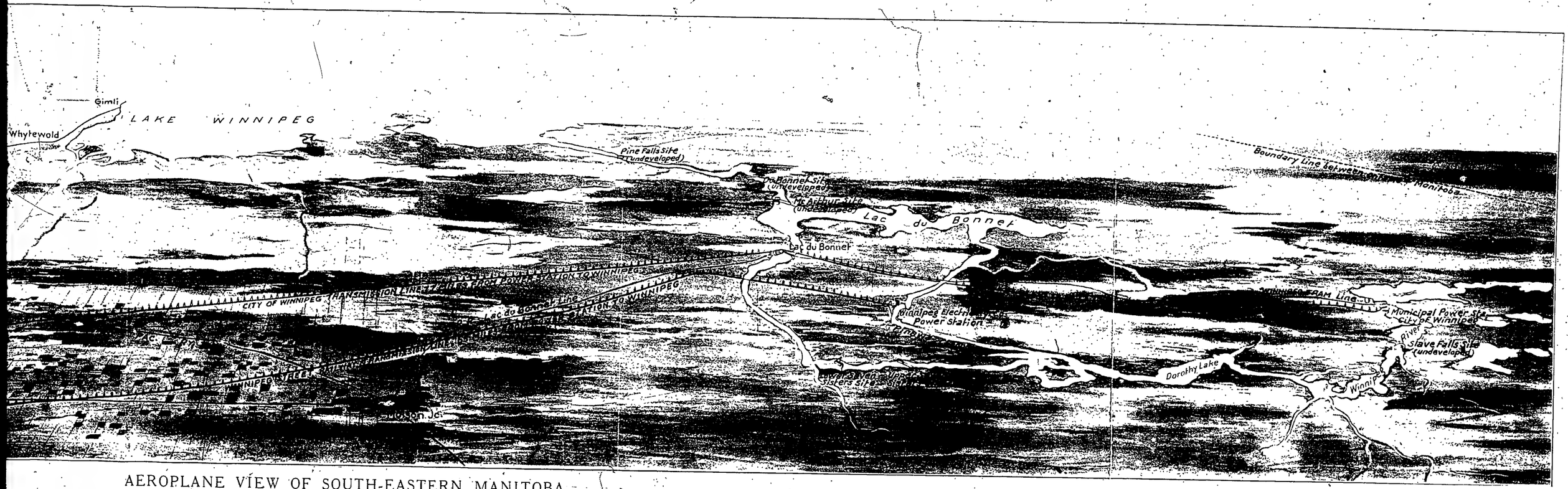


Lower Seven Sisters Falls.

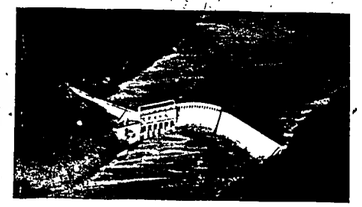


Upper Seven Sisters Falls.

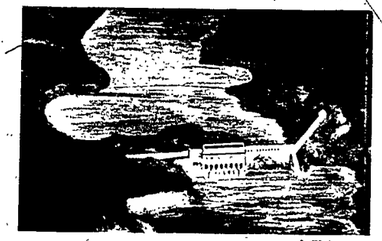
Dominion Water Power Branch Exhibit—Winnipeg Industrial Bureau.



AEROPLANE VIEW OF SOUTH-EASTERN MANITOBA



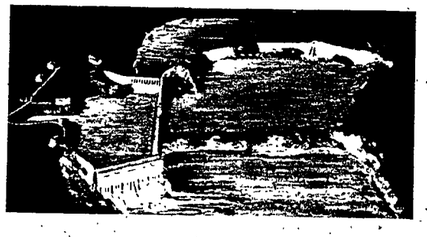
Lower Seven Sisters Falls.



Upper Seven Sisters Falls.

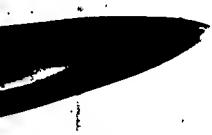
Winnipeg Electric Railway Plant, Pinawa Channel.

Slave Falls.



Winnipeg Municipal Plant, Point du Bois.

ion Water Power Branch Exhibit—Winnipeg Industrial Bureau, 1915



Coming down stream from Point du Bois the series of falls to be met with are the subjects of the Government investigation, and the description and proposed plan of development of each is presented in the following: -

SLAVE FALLS SITE

The proposed development at Slave Falls site concentrates a head of 26 feet formed by the combination of Slave and Eight Foot Falls. The dam runs along the crest of the falls and curving down stream through an arc of about 90 degrees, connects with the power station on the right bank of the river where provision is made for the future inclusion of a lock for water transportation, should this river be improved for navigation purposes. The head and

Winnipeg River. Seven Sisters, 1st Fall.

tailwater elevations, as at present proposed, are 928 and 902 feet above sea level respectively. The initial installation, on which the cost estimates are made, includes eight 5,000 h.-p. turbines sufficient to provide for a flow of 12,000 second feet under normal loading, with one unit reserved as a spare for emergencies. On a 75% efficiency basis, contemplating a combined loss of 25% in turbines and generators, 26,600 h.-p. will be available at a capital cost of $87.50 per h.-p. at the power house switchboard. The final installation includes thirteen 5,000 h.-p. turbines sufficient for the utilization of a flow of 20,000 second feet with one turbine reserved as a spare unit. In the latter case 44,400 h.-p. would be the commercial output for twenty-four hours per day, and the complete plant is then estimated to cost $77.39 per horse power at the switchboard. The annual cost per horse power on a one hundred

per cent. load factor, excluding transmission charges, is estimated to be $8.58 and $7.62 for the initial and final installation respectively.

THE SEVEN SISTER SITES

The Seven Sisters comprise a series of falls over a stretch of about 3½ miles and are capable of best development as two separate sites, the upper being composed of two falls and the lower including five falls in all.

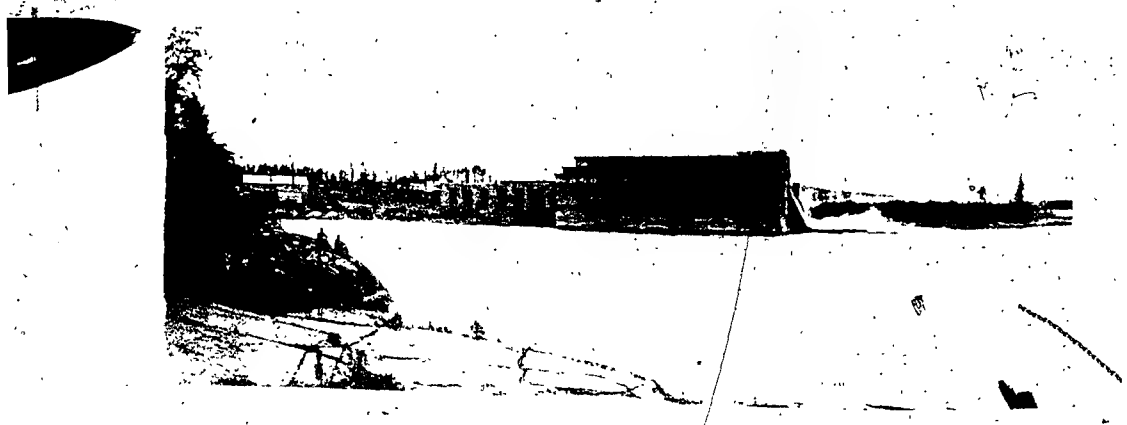
Immediately above the Seven Sisters Falls the Winnipeg Electric Railway has its intake on the Pinawa Channel, a cut-off on a large bend of river. This Pinawa Channel development is discussed at length later in this chapter.

The Upper Seven Sisters Site permits of a head of 29 feet being established, and with this head and 12,000 cubic feet of water per second, after allowing fully for the water requirements on the Pinawa Channel, and ultimate installation of eight 6,000 h.-p. turbines, one a spare, is proposed. On a 75% efficiency basis 29,600 h.-p. will be available at a capital cost of $92.00 per horse power at the power house switchboard.

The Lower Seven Sisters Site is located 8½ miles above the town of Lac du Bonnet and 82 miles from Winnipeg. The head here obtainable is 37 feet and fully considers the limits of manipulation of head and tailwaters so as not to encroach on the tail and headwaters of the sites immediately above and below this site. This plant is proposed to include six 10,000 h.-p. turbines, one being a spare. On a 75% efficiency basis, 37,900 h.-p. will be available at a capital cost of $89.95 per horse-power at the power house switchboard.

McARTHUR FALLS SITE

McArthur Falls is located immediately at the outlet of Lac du Bonnet, and is below the discharge of the Pinawa Channel, so that the full water capacity of the river is here available.



Generating Station, Point Du Bois.

Silver Falls, Winnipeg River.

A head of 18 feet may be created and an initial installation of eleven 2,500 h.-p. units and an ultimate installation of seventeen 2,500 h.-p. units is proposed, one unit in each case being a spare.

The river at McArthur Falls site is divided into two channels by a large island. The general arrangement of works consists of a solid concrete spillway along the crest of the fall on the right or main channel, and a long spillway and embankment, including sluiceway provision, running diagonally across the island and connecting with the power station spanning the left channel.

The capital cost involved in the initial plant is $110.38 per horse-power and in the ultimate completed plant $89.25 per horse-power. The annual cost per horse-power on a 100% load factor, excluding transmission, is estimated to be $10.82 and $8.86 per horse-power for the initial and final installations, respectively.

DU BONNET FALLS SITE

The proposed scheme of development at the Du Bonnet Falls will ultimately concentrate there a head of 56 feet made up of the Grand and Little Du Bonnet Falls and the Whitemud Falls, the latter being added by the blasting out of the rocky ridge over which the present fall takes place. The dam, consisting of embankment, spillway and sluiceway sections, leaves the left bank and crosses the river on the brink of the Little Du Bonnet Falls, connecting with the power station which parallels the right shore line below the pitch. Ice sluices and an embankment connect the power station with the high land on the right bank.

The initial installation is proposed to include seven 10,000 h.-p. turbines, later to be increased to 12 units. These first capacities are based on only 46 feet head and the unregulated and regulated flow of 12,000 and 20,000 second feet respectively, the Whitemud addition of two further units being made only for the ultimate development of 56 feet head when the installed capacity will produce 95,500 h.-p. over twenty-four hours at a capital cost of $68.60 on the switchboard, and at an annual operating cost of $6.65 per horse-power at 100% load factor.

This site is situated 64 miles from Winnipeg.

Winnipeg River. Pine Falls. Main Pitch from right bank.

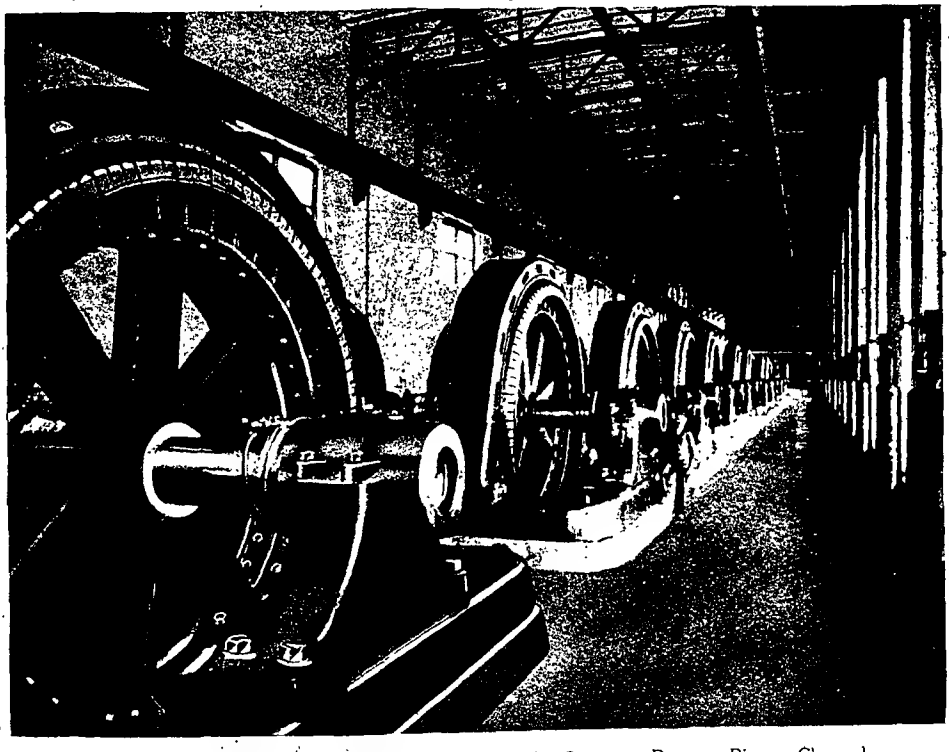
Winnipeg River.

PINE FALLS SITE

Pine Falls and Silver Falls are the nearest to Lake Winnipeg of the whole series. Combined these two falls have a head of 37 feet. The initial development, under 12,000 second feet flow, is proposed to include six 10,000 h.-p. turbines, and for the ultimate flow of 20,000 second feet ten such units would be installed, in each case a spare being included. The ultimate capacity would be 63,100 h.-p. of 24 hour power, which would involve a capital cost of $69.84 and an annual cost of $7.08 for power delivered on the switchboard.

This site, in common with all these here described, may be readily adapted to include locking facilities in the event of the use of this river in a comprehensive navigation scheme, as such would be greatly facilitated by the development of all the sites and erection of the necessary power dams.

The condition of the river bed and the excellent granite foundations available make the constructional features of all the sites particularly attractive. Railway and transportation facilities to the neighbourhood of the respective sites may be readily provided from short extensions to existing railways, and thus would be eliminated one of the greatest costs in power enterprises.



Winnipeg River. Winnipeg Electric Railway. Interior Generator Room. Pinawa Channel.

Lac Du Bonnet Plant Spillway.

WINNIPEG ELECTRIC RAILWAY COMPANY

As before mentioned the Pinawa Channel connecting the Winnipeg River by a short route to Lac du Bonnet from above the Seven Sisters Falls, is utilized by the Winnipeg Electric Railway to generate power for transmission to Winnipeg, a distance of 65 miles.

The Pinawa Channel is an old high water channel of some 25 miles in length, which has been improved and much enlarged. The water for the plant is directed into the Pinawa Channel from the main river by three diversion dams, the principal one of which consists of some thirteen hundred feet of concrete capped rock fill across the main channel, connected to the bank on either side by concrete spillway, bringing the total length to 1,650 feet. The small weirs of timber crib type span secondary channels. The water thus diverted flows down the improved channels to a control dam which is capable of shutting off the flow and returning a portion, or all of it, to the main river over the waste or diversion weir. From the control dam the water flows through the tortuous bed of the old high water channel, this having been deepened and partially straightened by excavation. The power house is situated at a bend in the channel where a concrete dam with arched spillway creates 39

foot head, the tailrace which is the lower part of the channel being also much enlarged and improved.

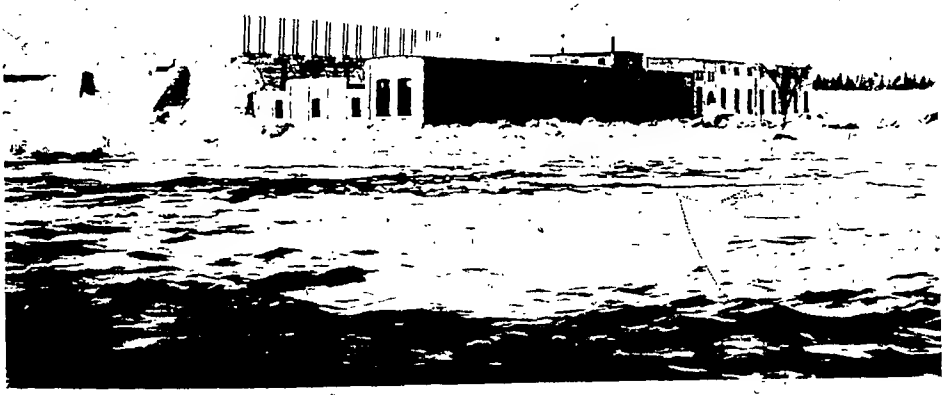
In this plant are installed four 1,000 Kilowatt and five 2,000 Kilowatt generators having a combined output capacity of 28,200 h.-p., which is further augmented by a steam generating plant in the City of Winnipeg, having a capacity of 13,600 Kilowatts and by a storage battery capable of carrying a load of 3,000 Kilowatts for one hour.

The power is transmitted over duplicate circuits on a steel tower line at 60,000 volts, and is distributed and utilized in a varied market of domestic, industrial, commercial and electric railway loads.

WINNIPEG RIVER POWER COMPANY

The hydro-electric development of the Winnipeg River Power Company, on the lower Winnipeg River, was the first undertaking to test the general efficiency and usefulness of the Departmental field studies. The Company has been authorized to develop the above described du Bonnet site. Earlier proposals of the Company had involved the elimination of an excellent power prospect further up the river. Acceptance by the Company of the Government power scheme kept this upper site free for future exploitation and, in addition, resulted in a more economically efficient development for the Company.

The general principles of head and tail water elevations and of discharge and safety requirements, etc., were accepted by the Company. Further detailed explorations of the river bed prior to construction, resulted in the location of a more desirable site about $\frac{3}{4}$ of a



Winnipeg Electric Railway Company, Power House of Pinawa Channel, Winnipeg River.

mile below the du Bonnet site. Here definite arrangements are being made for the immediate construction of what has been named by the Company, the Great Falls development.

The general layout proposed consists of a power station spanning the channel to the left of a central island, tied in to the left river bank by a non-overflow concrete dam, 900 feet in length. The power station is joined to the right river bank by a gravity section concrete dam of a combined sluiceway and free spillway type, 2,100 feet in length. A core-wall embankment connects the free spillway with the high contour on the right bank. The dam provides sluice discharging capacity for 70,000 cubic feet per second at regulated level, while 1,570 feet of free spillway with crest at elevation 808 will, with a six foot overtop, automatically care for the greatest anticipated floods.

The present plans for the power station provide for the installation of eight 21,000 h.p. turbines, operating under a head of 56 feet. The turbines are of the four runner horizontal shaft type, placed in pits formed in the concrete substructure. The turbines are direct connected to eight 11,000 Kilowatt generators, generating three phase, 60 cycle, alternating current at 12,000 volts. Individual exciters are provided for each machine, direct-connected to the shafts, while in addition an auxiliary motor driven exciter is also provided.

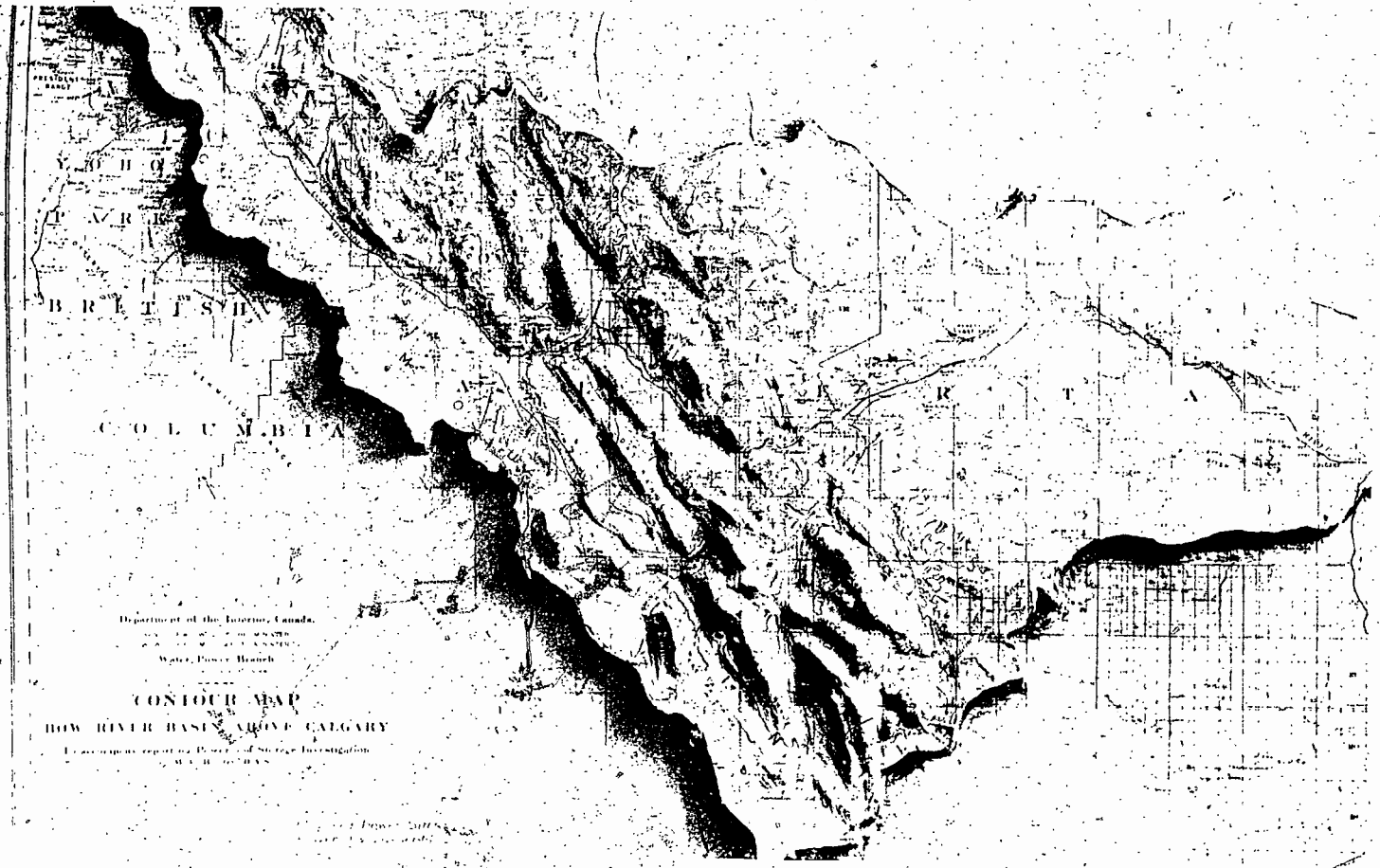
Five banks of transformers, each bank consisting of three single phase 6,000 Kilowatt transformers, designed to safely withstand a continuous overload of 50%, will transform the generated current from 12,000 to 110,000 volts, for transmission to the Winnipeg market.

The initial development will consist of four complete units.

WATER POWER ON THE BOW RIVER

THE Bow River has its source in the mountain lakes and streams and in the glaciers and snowfields of the Rocky Mountains. It drains an area of 3,138 square miles on the eastern slope of the mountains immediately west of the City of Calgary, in the Province of Alberta. The waterfalls are numerous as from the farthest of its headwaters, up in the mountains, 6,500 feet above the level of the sea, it falls 2,750 feet to Kananaskis Falls where the Kananaskis River joins the Bow, and from Kananaskis Falls to Calgary, a distance of 55 miles, a further drop of 720 feet takes place. It is in this latter stretch that the most promising power sites exist and where the three Bow River developments at Eau Claire, Horseshoe Falls and Kananaskis Falls are situated.

Above Kananaskis Falls the entire drainage area of 1,710 square miles lies wholly within the Rocky Mountains National Park of Canada, and by the conserving and co-operating policy of the Parks administration, the extensive storage possibilities are readily available of full utilization, and already considerable storage has been created. The flow of the river, as in all mountain streams of this character, is subject to sudden variation and is greatly influenced by conditions of temperature. During the winter months the flow is held in check, but in the hot summer months of June and July the melting winter snows and the glaciers loose their floods which rush through the mountain gorges to the Bow, down the Bow to the Saskatchewan and to Lake Winnipeg, then down the Nelson to the sea. The



Contour Map of Bow River Basin above Calgary.

summer floods are very great compared with the winter flow, a flood of 45,000 cubic feet per second being measured on the Bow River just above the confluence of the Kananaskis while a low water flow of 500 cubic feet per second has been measured at the same point.

From Bow Lake, the source of the River, down to Laggan, the river flows for the most part through a wide valley in the midst of towering mountains. Below Laggan, as far as Kananaskis Falls, the valley traversed is wide, flat and covered with gravel, and the stream is tortuous in its course. In two or three places in the main valley above Banff small lakes occur, probably formed by the damming off of part of the old river course by the material carried down from the surrounding mountains. Below Banff, near Exshaw, the river widens

Bow River.

out and covers the greater part of the valley. At Kananaskis Falls an abrupt change in the topography of the country takes place; this, it may be said, is due to the fact that the river leaves the mountains proper here and flows out into the foothills, these conditions continuing as far as Calgary.

The Elbow River flows into the Bow immediately below Calgary from a southerly direction. Its power possibilities are dealt with in the next succeeding chapter.

For purposes of description the Bow River above Calgary may be conveniently considered as of two economic portions, that above Kananaskis Falls being a storage section, and that below the power section.

From Kananaskis Falls, nearly to Calgary, the river flows through a wide valley for long stretches; the river proper is confined, however, to its channel by steep banks that at different

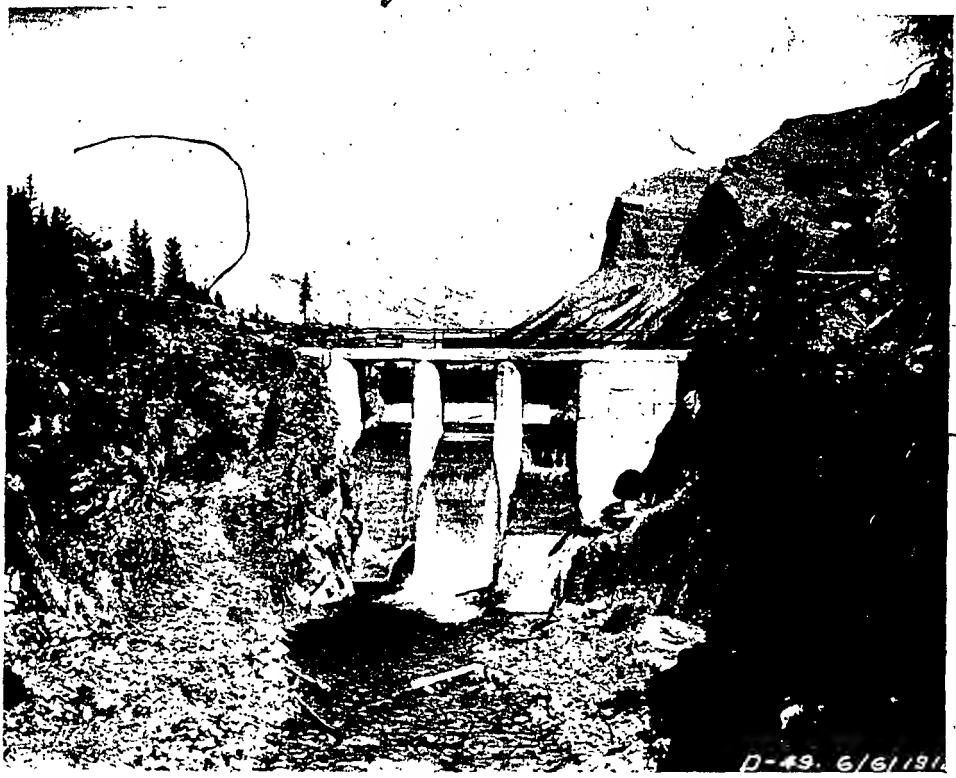
points are rocky cliffs of considerable heights running as high as from one hundred to one hundred and fifty feet. Generally these cut banks have long sloping banks opposite to them, but in places the river channel is canyonlike for short stretches and is thus readily adaptable to power development works.

The storage section of the river, a stretch of approximately 90 miles in length, lies to the west of Kananaskis Falls, and entirely in the mountains. Nearly all the streams flowing into the Bow River have, at or near their source, a lake of greater or less size. The larger lakes include the Bow and Hector lakes at the highest elevations; Lake Minnewanka, near Banff, at the head of Cascade River; the Spray Lakes at the head of the Spray River; and at the headwaters of the Kananaskis River, Kananaskis Lake. Other lakes, many far famed for their scenic beauty, which are extremely valuable for their regulating effect, but not so suitable as controlled storage basins, include Lake Louise at Laggan; Ptarmigan, Baker and Redoubt Lakes; Moraine Lake, in the valley of the Ten Peaks; and Boom Lake and Shadow Lake.

The rapidly increasing demand for power from the Bow River, and the necessity for providing adequate storage facilities for existing and contemplated plants on the river, rendered necessary the exhaustive investigation of the River's resources as to power capacities and regulation, and, at the same time, to enable the formation of a policy providing for the most advantageous realization of these sources in the best interests of present and prospective users both for power and irrigation. To meet these ends the Dominion Water Power Branch during the seasons of 1911, 1912 and 1913 instituted aggressive surveys and investigations

Bow Lake.

Spray Valley looking north from Hub L.

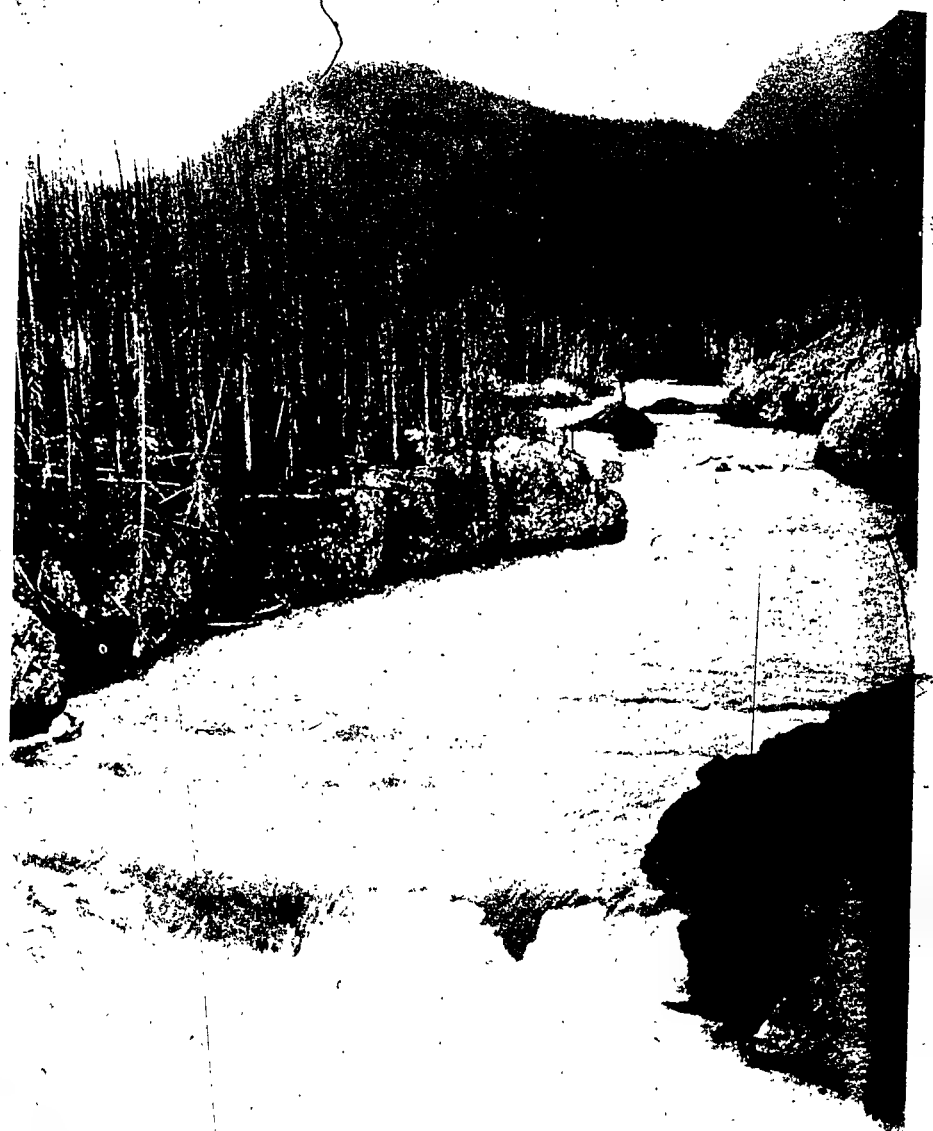


Minnewanka Dam, near Banff, Alberta.

into the power and storage possibilities of the river and watershed. These studies were compiled into a report which designates the suitable lakes and the possible improvement by their use, and further determined the feasible power sites, indicating the method of development to secure the most efficient results. The report has been published as "Water Resources Paper No. 2".

All feasible storage on the Bow River above Calgary is fortunately available for the whole water stretch of the river. The mean flow for the winter months has been 720 cubic feet per second, but by means of the storage that has been, and may be created, it is anticipated that the mean flow can be increased to about 1,500 cubic feet per second. The effect of such storage upon the power output is to raise the winter mean output of 19,785 h.-p., on the six sites which will be later described, to 48,175 h.-p., and in addition a plant to be constructed on the Cascade River and supplied by water in transit from the Minnewanka storage lake would be capable of producing 1,165 h.-p.

The Minnewanka storage system is now complete and includes a dam at the head of the Cascade River. This is shown in the reproduction above, the gorge immediately below the dam, called the "Devil's Canyon," being shown in reproduction on page 37. In the



River above Falls.

former photograph may be seen the penstock connection in the dam placed to connect with the works to be built for the Cascade River power development.

The existing plants on the river are worthy of detailed mention as being in themselves of interesting construction, and further being possibly representative of the form of developments which may be expected for the present available sites. These plants are the Eau Clair, in the City of Calgary, and the Horseshoe and Kananaskis Plants of the Calgary Power Company.

EAU CLAIR PLANT

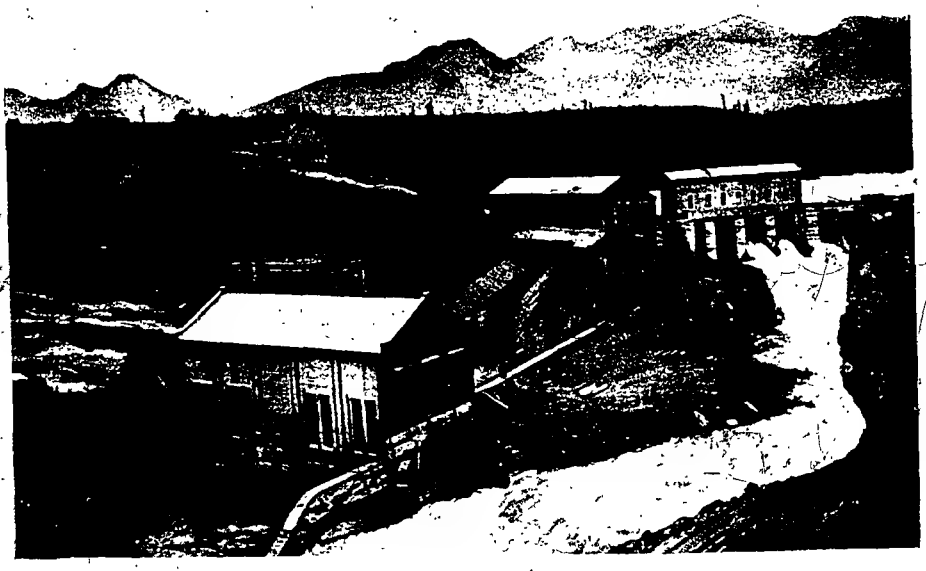
This was the first hydro-electric plant on the Bow River, and was developed by the Eau Clair Lumber Company, within the City limits of Calgary. While the initial type of contruction used for development was not of the most permanent character, the possibilities are excellent for the construction of a very efficient plant at this point, utilizing the present head of 12 feet. The present capacity is 600 h.-p., which is used for lighting under a City franchise. This small plant is augmented by a steam plant and has thus become a very reliable source of power.

HORSE SHOE FALLS PLANT

This plant is located at Horse Shoe Falls, about 50 miles west of Calgary, and at this site is one of the very few concentrated falls to be found upon the Bow River.

The Bow River, at the Horseshoe Falls, in its natural state, flows through a deep gorge, the walls and bed of which are formed of a shale banded with sandstone. At this point a massive outcropping of inclined rock intervenes, and as time passed a channel was eroded through this natural dam and a fall of some 25 feet occurred. A solid concrete dam

Devil's Canyon, Outlet of Lake Minnewanka, Banff.



Bow River. Horseshoe Falls. Calgary Power Company's Development.

has been built across the gorge on the lip of this outcrop, and this, with the natural fall, produces a head of 70 feet.

The reproduction above capably shows the whole development.

The dam is of solid spillway type with an inspection and drainage tunnel. In addition to this spillway there are a number of sluiceways provided to take care of flood discharges. Inspection tunnel, access to which is gained by means of a well, situated between the flood discharge openings, extends under the spillway section into the rock at the west abutment of the dam. Four penstocks are installed leading from the intake to the power house which, is situated in the gorge below.

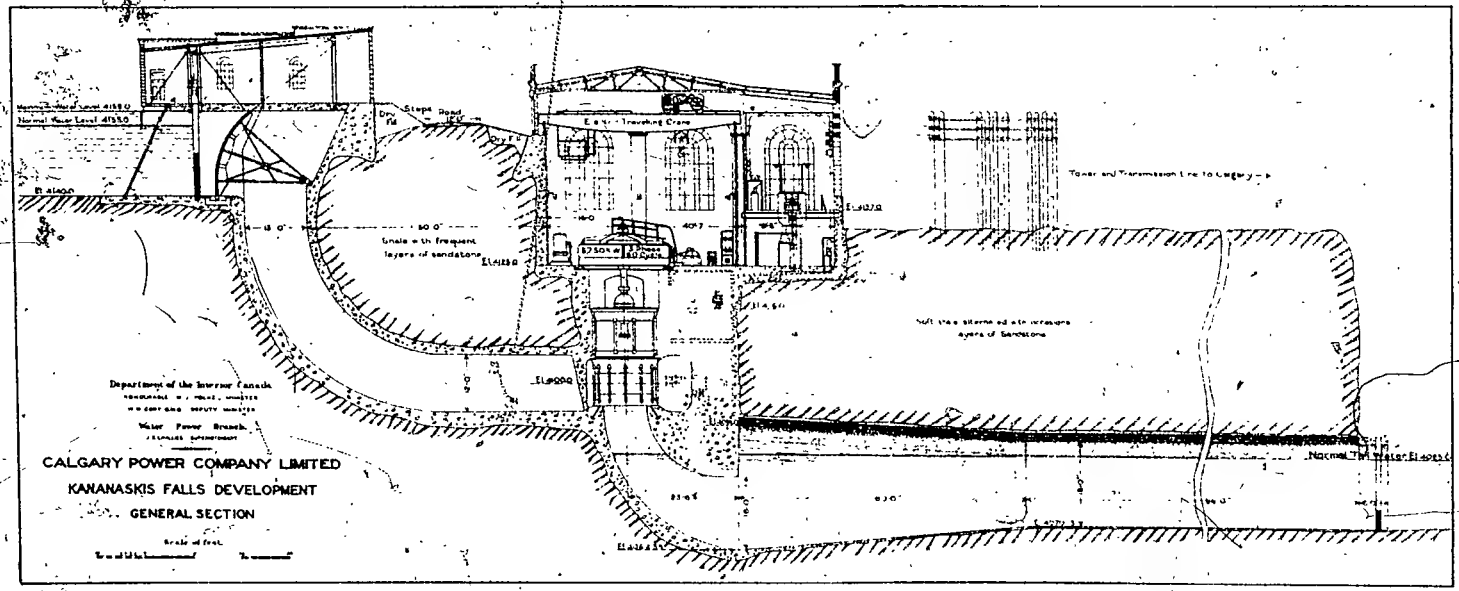
The complete power equipment consists of four turbines, two being of 3,750 h.-p. capacity and two being of 6,000 h.-p. capacity each. The electric generators are direct connected and and produce their power at 12,000 volts, this being stepped up by transformers to 55,000 volts for transmission to Calgary. A portion of the power is transmitted to Exshaw for use in cement mills direct at the generator voltage of 12,000 volts.

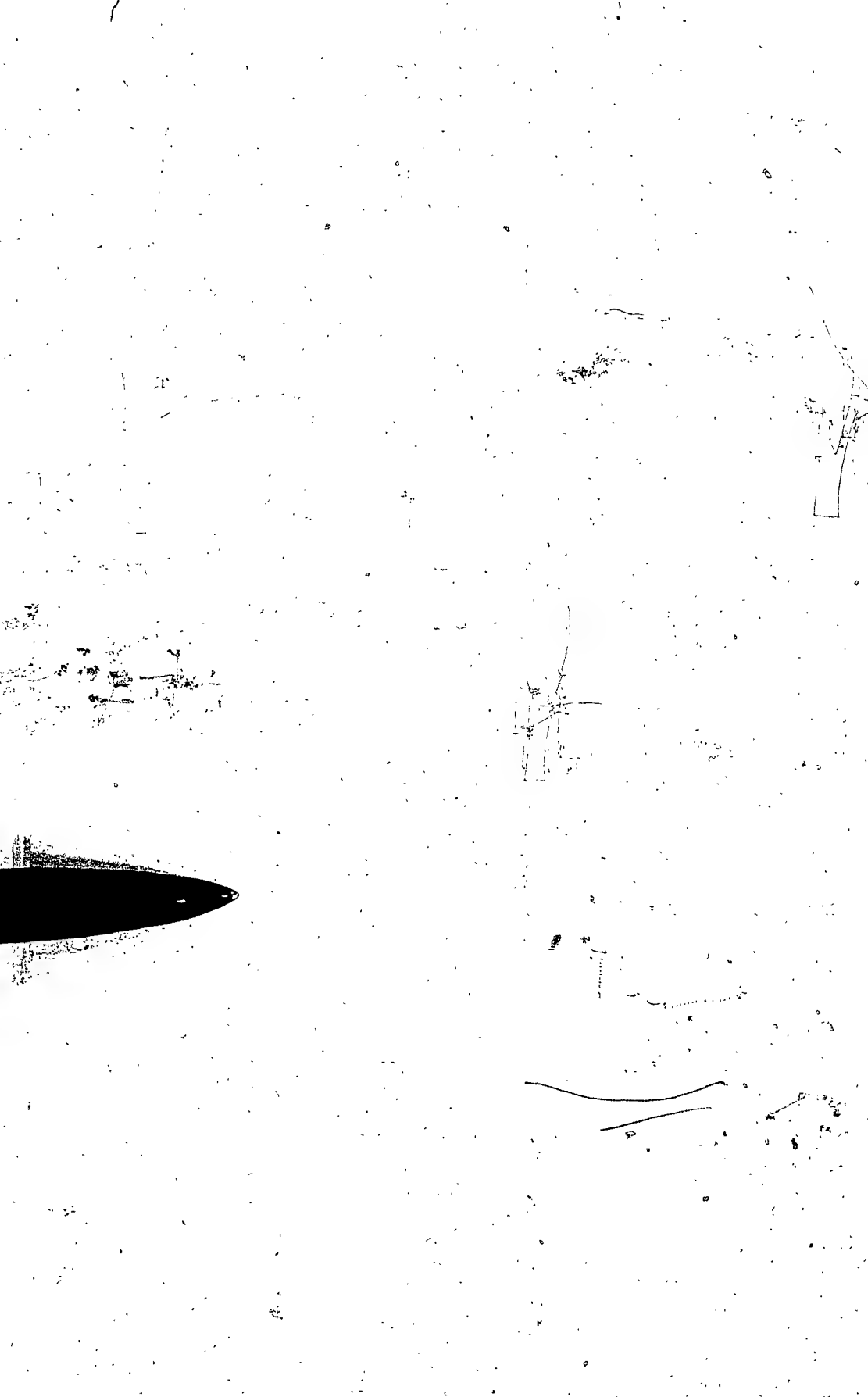
The transmission lines, in duplicate, are of aluminum cable on wooden poles.

KANANASKIS FALLS PLANT

The site of this plant is at the Kananaskis Falls, immediately below the junction of the Kananaskis and Bow Rivers, and about two miles above the Horseshoe Falls.

The head is composed of rapids and a series of three falls, giving a total drop of approximately 55 feet. Above the rapids, the Bow is wide and fairly shallow, while the banks are comparatively low, but gradually increasing in height to the head of the falls. Below the


Department of the Interior Canada
Water Power Branch
CALGARY POWER COMPANY LIMITED
KANANASKIS FALLS DEVELOPMENT
GENERAL SECTION
Scale of feet
Slope Paving
Tower and Transmission Line to Calgary
Normal Tail Water Elevation



falls the banks are perpendicular, the river flowing through a rather wide canyon. The banks of the Kananaskis are high, the west bank being perpendicular and rising at least 40 feet above the surface of the stream; the slope of the east bank is more gradual for the first few hundred yards, but after that it is high and abrupt.

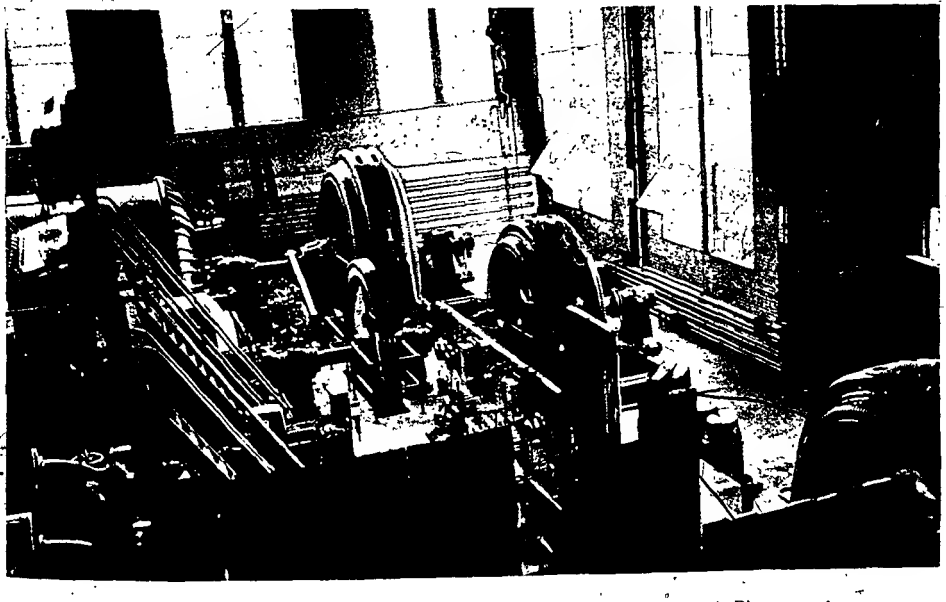
The development adopted includes a dam placed across the head of the falls, raising the water and diverting it into a canal excavated on the south side of the river, which conveys it to the intake. The water from the intake is conveyed in tunnels to the turbines in the power station. The turbines are of single runner type, with vertical shaft, and utilize the created head of 70 feet.

The turbines are at present two in number, each of 5,800 h.-p. capacity, direct connected to a generator. The voltages of 12,000 on the generator and 55,000 volts on the transmission line correspond to the characteristics of the electrical output of the Horseshoe Falls plant to which it may be connected to operate in parallel, the two plants being owned and operated by the same Company to serve the same markets.

The load contracted for in bulk has rapidly increased, the initial contracts being 5,500 h.-p. in 1911 and increasing to 13,000 in 1914, a rate of growth which fairly well seems to be established for power plants supplying Canadian Cities.

Illustrations particularly referring to this development are on page 41, showing the Kananaskis Dam, and facing page 38, showing the cross section of the Kananaskis Generating Station and Intake works.

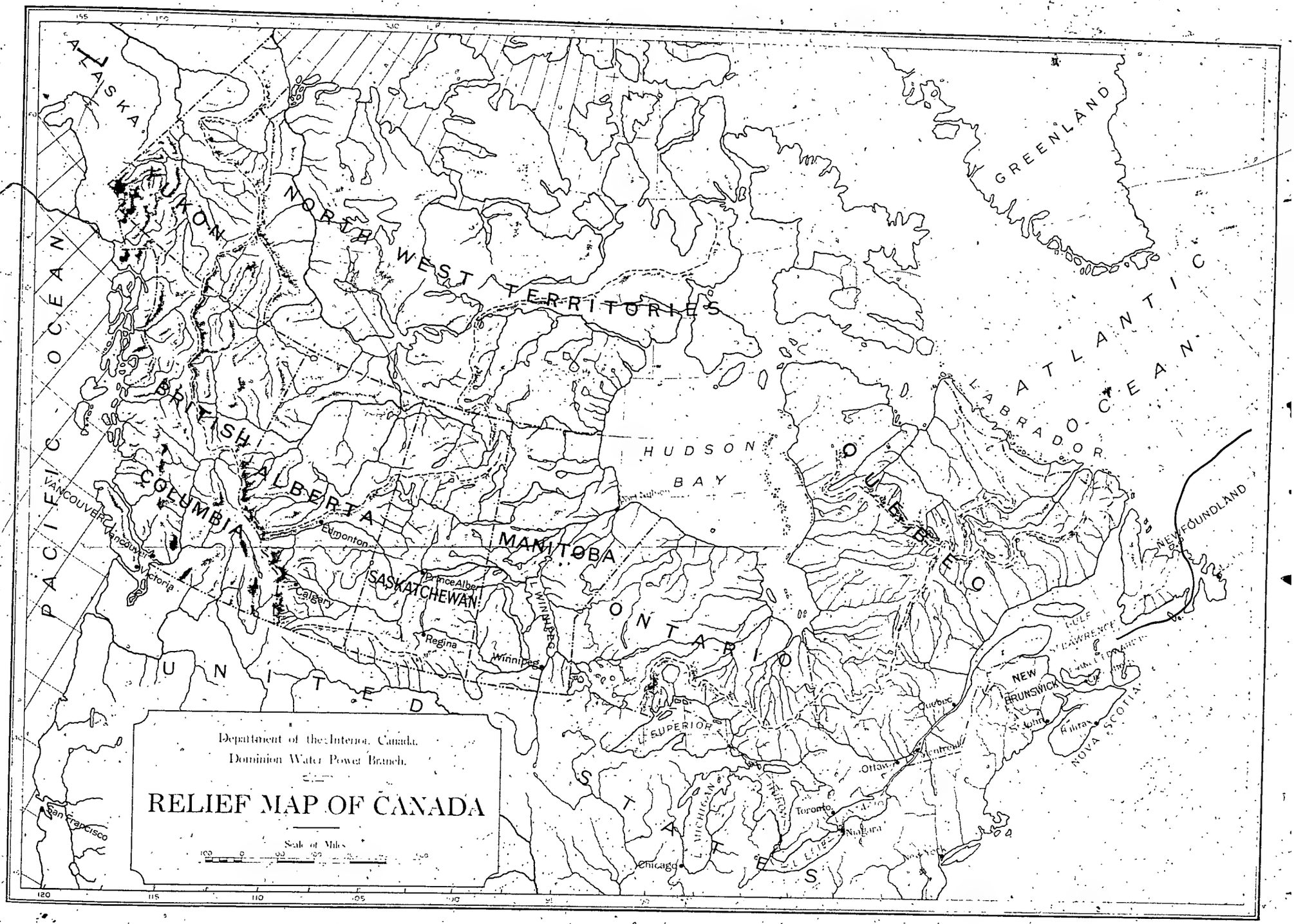
From an engineering point of view one feature common to both these developments is very interesting. After unwatering the sites and examining the foundations, the seams in



Bow River. Horseshoe Falls. Interior Calgary Power Company's Plant.

Lower Kananaskis Falls Bow River

Kananaskis Falls, Bow River.


ALASKA
YUKON
NORTH WEST TERRITORIES
GREENLAND
PACIFIC OCEAN
ATLANTIC OCEAN
LABRADOR
HUDSON BAY
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEWFOUNDLAND
NEW BRUNSWICK
NOVA SCOTIA
GULF ST LAWRENCE
UNITED STATES
Vancouver
Victoria
Edmonton
Calgary
Prince Albert
Regina
Winnipeg
L. WINNIPEG
L. SUPERIOR
L. MICHIGAN
L. ERIE
Ottawa
Montreal
Quebec
Toronto
Niagara
Chicago
New York
San Francisco
Halifax
St John
Department of the Interior, Canada.
Dominion Water Power Branch.
RELIEF MAP OF CANADA
Scale of Miles
100 0 100 200 300 400 500
120 115 110 105 100 95 90 85 80 75 70

the stratified formation were suspected of providing a means of excessive leakage, and to obviate any such occurrence, a series of three inch holes were drilled 10 feet apart, immediately in front of the respective dams to a depth of 40 feet. Into these holes was poured a grout mixture of cement, and the seams spreading from the holes were effectually filled and the foundation rendered impervious.

LAKE LOUISE PLANT

This plant, while very small and scarcely to be considered from a commercial stand point, nevertheless, is an existing development in the Bow River system.

The power station is situated about half a mile from the Lake Louise Chalet, the Canadian Pacific Railway Hotel at this mountain resort, to which the 75 Kilowatts of power is delivered.

The water is conveyed from Lake Louise in a 20 inch wood stave pipe, 2,800 feet long to the turbine, under a head of 140 feet, and discharged into Chalet Creek, the outlet of Lake Louise.

POSSIBLE DEVELOPMENTS ON THE BOW RIVER

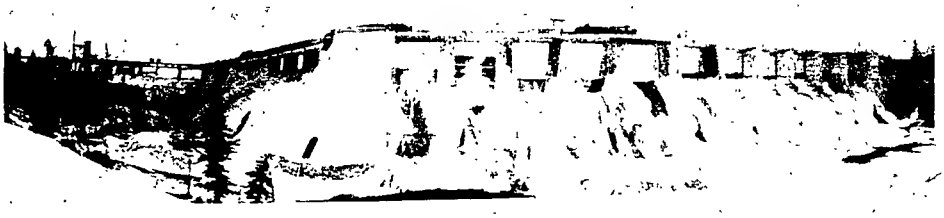
The sites on the Bow River which have been selected as particularly adapted to development are the Bow Fort, the Mission, the Ghost and the Radnor.

BOW FORT SITE

The Bow Fort Site is located about four miles below Horse Shoe Falls at the foot of a number of rapids and swifts which aggregate 70 feet of fall below the tailwater of the Calgary Power Company. The site available for the dam is excellent, as suitable foundation rock exists in the river bed, and the banks of the river are steep and rocky, and but 265 feet from cliff to cliff.

A head of 66 feet may be created by the dam allowing two feet leeway for operation of the Calgary Power Company's tailwater. The intake, also constructed in solid rock, would be situated on the south side of the river and would direct the water into the three power penstocks, each proposed to supply a turbine of 4,400 h.-p. capacity, coupled to a generator of 2,500 Kilowatts with exciter direct connected.

This power site is an ideal one as the construction works are simple and comparatively inexpensive.



Kananaskis Dam.

The cost has been estimated from the preliminary plans prepared for the development along the lines here outlined, and aggregate a total of $138.00 per horse-power, including a proportionate cost of transmission to Calgary, along with the other proposed plants further down the river. The annual cost, per horse-power, on a 100% load factor is estimated to be $15.93. All costs given for these sites are for the rated capacity of the equipment and for power delivered in Calgary; the stations are capable of operating on 25% overload above the rated capacity continuously.

MISSION SITE

Below the Bow Fort Site the river flows through a wide valley bottom, with high banks on either side, and after a series of flat rapids the river passes between two high rocky banks some 450 feet apart, which afford an excellent site for a dam.

With a dam in this suitable location the water may be carried in an open canal across the rocky terrace adjoining the dam to a bend in the river where the power house would be situated about 6,000 feet below the dam. The head thus to be obtained is 47 feet.

As in the Bow Fort proposed design this plant would be arranged with three penstocks leading from the intake head-works on the canal to the power house where three turbines, each with 3,500 h.-p. direct connected to generators with their exciter, would be installed.

The cost of such a plant would be $173.00 per horse-power, and the annual cost of power would be $19.37 delivered in Calgary.

GHOST SITE

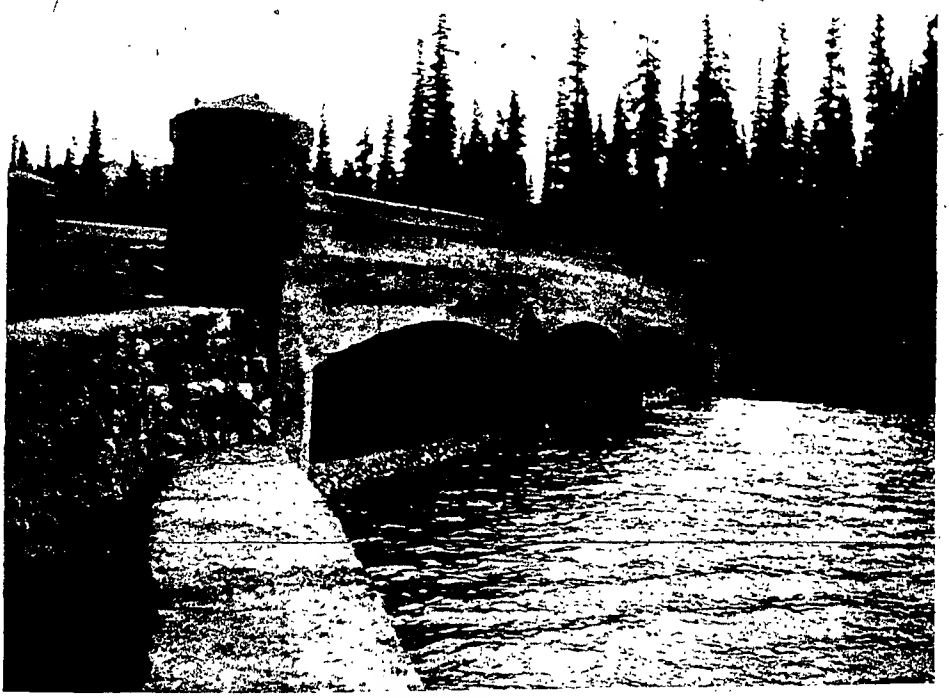
Four miles below the Mission Site is the Ghost Site, so called on account of its situation at the mouth of the Ghost River. The rocky outcrop, forming the falls, is readily adapted to receive a dam using the outcrop on each shore as its abutments. As this is below the entrance of the Ghost River the water is appreciably augmented by the 100 cubic feet per second flow in the Ghost River.

The intake would be placed on the south bank, the water being carried by a rock canal, as in the Mission proposal, though less in length. A head of 50 feet is obtainable, and the plant is designed to have three turbines each of 3,500 h.-p. capacity direct connected to a generator and exciter.

The cost of the Ghost plant, including transmission, will be in the neighbourhood of $163.00 per horse-power, with a consequent annual charge for power of $18.73 delivered in Calgary.

RADNOR SITE

Below the Ghost Site the river is composed of swifts and rapids so that any development requires the concentration of the natural slope of the river at one point. The location of the dam has been selected about 3½ miles below the mouth of the Ghost River, between perpendicular rocky banks. A canal will be excavated on the north side in the cliff alongside the river, the outer wall of the canal being in the nature of a concrete retaining wall



Lake Louise Power Development. Upstream face of Bridge.

which will also act as additional spillway. This canal would be short leading into three penstocks.

The turbines terminating the penstocks would be three in number, each of 3,500 h.-p., operating under 44 feet head.

The cost of the Radnor plant, including transmission, would be about $167.00 per horse-power installed; and the annual cost of power in Calgary will be $19.25 per horse-power.

CASCADE POWER DEVELOPMENT

When contemplating the creation of storage on Lake Minnewanka, the question was raised as to whether it would be feasible to build a power plant in connection with the storage scheme and produce electrical power for consumption in Banff. Banff, together with the storage basin and drainage area developed, lies entirely within the boundaries of the Rocky Mountains Park, and as the affairs of the town are administered by the Dominion Government, through the Parks Branch of the Department of the Interior, the same authority would carry out the work. A complete investigation of the power possibilities in connection with the storage dam was therefore undertaken with this end in view.

The canyon of the Cascade River, in which it is proposed to develop power, lies directly below the junction between the Cascade and Devil's Creek, the latter forming the outlet

of Lake Minnewanka. The area tributary to the river at this point is approximately 220 square miles, of which Lake Minnewanka forms about 6 square miles. The greater portion of this basin lies at considerable altitude, the entire water supply coming from mountain streams, springs and glaciers.

At the entrance to the canyon, and just below the confluence of the two creeks, the storage dam, previously described and shown in reproduction on page 35, was built.

The site of the proposed power plant is about seven miles from the town of Banff, with which it is connected by an excellent parks roadway. Any development at this point will be entirely under the jurisdiction of the Government, and all privileges, such as land, water, rights-of-way, and so forth, are vested in the Crown.

In the storage and discharge of Lake Minnewanka water allowance has been made for a continual flow of 150 cubic feet per second through the dam, which will be available for power purposes. Further, as the electrical load in the Town of Banff will be heaviest in the summer months, corresponding to the period of flood flows, the needs above the power capacity of 150 cubic feet may be readily met by waste water, and in no wise interfere with the filling of the storage basin in the early summer, nor deplete the stored supply.

The power house is designed to be located about 1,800 feet downstream, the water being led to it by a steel penstock from the dam to a rock tunnel in the side of the gorge about 100 feet downstream from the dam; the tunnel will emerge just below the most picturesque portion of the canyon, and will span the river in a steel tube, suitably masked and rusticated to preserve the scenic effect: from the river crossing the penstocks will be in the form of a wood stave pipe 1,100 feet long to the power house.

Bow Fort Dam. Site looking up river.

The power house will contain three generating units, each composed of a 600 h.-p. turbine, in a scroll case direct connected to a 350 kilowatt generator and an exciter. The power will be stepped up in voltage to 13,000 volts for transmission over duplicate lines into Banff. A comprehensive Parks lighting system in the town and vicinity is contemplated, and a general market for lighting, heating and small powers exists, capable of being developed to require the full load of the power plant.

THE WATER POWERS IN GENERAL

POSSIBLY the most logical method of describing the various developments and power possibilities throughout these provinces is to deal with the respective main drainage areas. The larger rivers, to which many of the power producing rivers are tributary, are: the Saskatchewan, those flowing into Lake Winnipeg, including the Winnipeg River which has been previously described, and the Nelson, which drains Lake Winnipeg, all of which form the first great group which flow eastward into Hudson Bay; the Churchill, also flowing into Hudson Bay, is the second great system; the Athabaska and Peace Rivers, which join the Mackenzie, and flow into the Arctic Ocean, comprise the third great watershed. Besides these rivers and systems there are many others flowing into Hudson Bay and into the Arctic Ocean, about which varied estimates of enormous power possibilities have been made, but with more or less inaccuracy, and as they are so extremely remote from present markets, and now appear to be so for so many years to come, that they do not at present warrant investigation to secure more reliable information. Many events may occur, however, now unthought of, to bring such potential water powers into immediate use as the immense mineral resources of Canada extend broadly into the most remote regions. The Yukon, for instance, comparable with the whole great north land, so quickly came into prominence, and here water power to-day holds a very important place, one plant whose product is wholly consumed in gold mining operations, producing 10,000 h.-p.; the watershed of the Yukon, which includes practically all of the water within the Yukon territory, is not treated further as the power consuming district is at present confined to a very small centre.

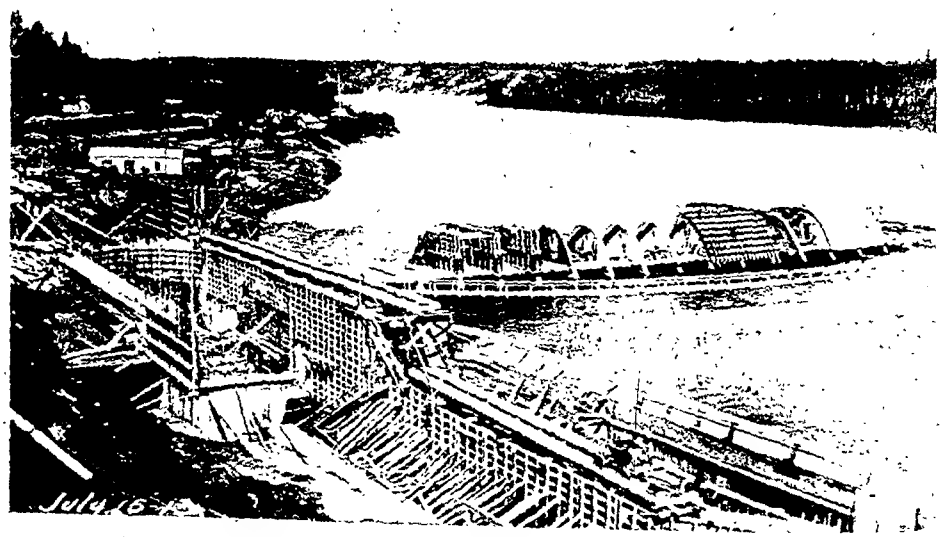
THE SASKATCHEWAN RIVER AREA

The Saskatchewan River is in two sections, the North Saskatchewan and the South Saskatchewan. Both these rivers rise in the Rocky Mountains, the headwaters of the South Saskatchewan including the Bow and the Elbow Rivers, both of which are treated more in detail in these chapters. The forks of the Saskatchewan are about 30 miles below the City of Prince Albert, the combined rivers flowing eventually into Lake Winnipeg

THE NORTH SASKATCHEWAN

The North Saskatchewan has its headwaters in the mountains southwest of the City of Edmonton, and 60 miles above Edmonton a power site is proposed at Rocky Rapids where the

North Saskatchewan River at Rocky Rapids, Alberta.



Lock and Dam, Cole Falls.

topographical features readily admit of a storage and power dam being built across the river, impounding an immense body of water capable of producing at a head of 85 feet 30,000 h.-p. for the Edmonton market.

While the North Saskatchewan has a considerable fall throughout its length, the gradient is very gradual and the river banks generally low. The most pronounced fall is at Cole Falls, about 25 miles below the City of Prince Albert, where a power plant is at present under construction by the City, the power requiring transmission but a short distance to their market.

Grand Rapids, Saskatchewan River.

The damming of the river at Cole Falls will greatly improve the river for navigation purposes, and to conform to the Government's intentions, in this respect, a lock has been constructed in connection with the dam. The reproduction on page 49 shows the lock and dam at Cole Falls during the construction period.

THE SOUTH SASKATCHEWAN

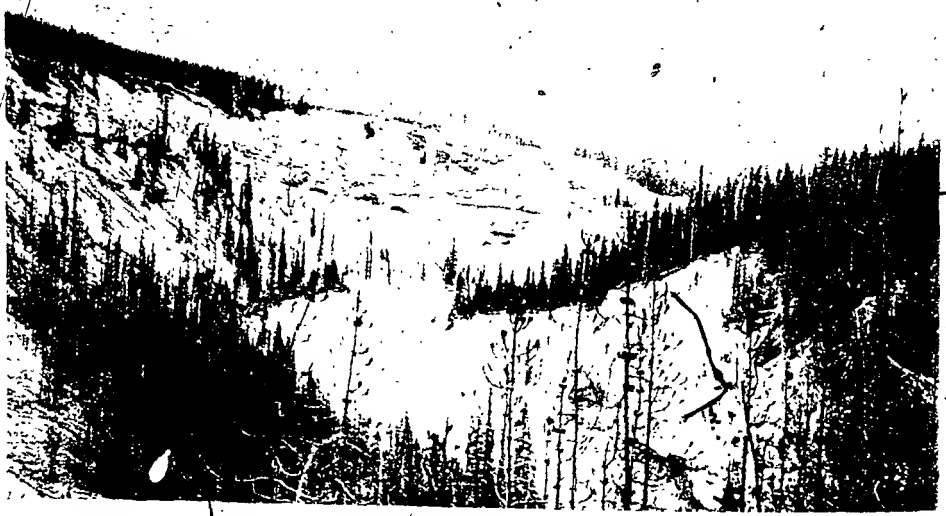
Similar conditions of gradient also occur in the South Saskatchewan River which flows for the most part through the prairie country. The many interests of towns and cities in the southern portion of Saskatchewan, particularly, where the natural water supplies for Municiple consumption have not been fully able to keep pace with the demand, have been responsible for the proposal of a diversion scheme, whereby the water would be dammed into a storage basin and pumped up to the adjoining heights of land to be distributed by gravity

to the various centres along a pipe line 170 miles in length. The Municipalities are proposing the diversion of 100,000,000 imperial gallons per day, the low water flow being in the neighbourhood of 800,000,000 gallons per day. In the pumping operations about 12,000 h.-p. is required, the greater portion of which is, according to one proposal, to be obtained from the water power produced by the dam. If the more complete study will substantiate the possibilities in these proposals, the diversion of the necessary water would possibly be compensated for to a considerable extent by the water storage and regulation in connection with such a power project.

Below the forks of the Saskatchewan at least five excellent power sites are available; one, at Grand Rapids, being particularly noteworthy. At the latter site about 40,000 h.-p. of continuous output may be developed, which would be materially increased by any possible storage basins in the river above, as about six months of the year water for over 300,000 h.-p. is available.

THE ELBOW RIVER

The Elbow River, one of the headwaters of the South Saskatchewan River, lying within the Rocky Mountains, is one of the main tributaries of the Bow River, previously described. This river, by its economical proximity to the City of Calgary, and on account of the application from various sources for development privileges, has been the subject of a very complete study by the Government, the complete results of the investigation being presented in the report of the Bow River Power and Storage Investigations, "Water Resources Paper No. 2."



Elbow River above Power Dam Site.

The main features of a development on the Elbow River involve a large dam and the impounding of an enormous quantity of water for seasonal storage.

The power development proposed contemplates a solid arched dam 130 feet high and 536 feet wide on the crest, impounding 21,100 acre feet of water, which would be utilized by passing through a rock tunnel 14,600 feet long in the adjacent mountain, and carrying through a penstock from the tunnel, a combined distance of over four miles to the power house where two 5,000 Kilowatt generators would be installed.

The power would be transmitted a distance of 33 miles on duplicate lines, on steel towers, to Calgary, where it is expected to be delivered at a most attractive figure.

LAKE WINNIPEG TRIBUTARIES

The rivers with favourable power possibilities entering into Lake Winnipeg, besides the Winnipeg and Saskatchewan, are the Fairford and Dauphin Rivers, the Waterhen, the Red River, Manigotagan, and the various rivers flowing into the east side of the lake, which will be dealt with as a group.

FAIRFORD AND DAUPHIN RIVERS

The Fairford and Dauphin Rivers, together with Lake St. Martin, form the connecting link between lakes Manitoba and Winnipegosis and Lake Winnipeg. This river system drains an area of 31,900 square miles, lying for the most part within the Province of Manitoba.

From discharge measurements available it is estimated that the minimum flow of the river system would not be less than 5,000 second feet, and furthermore that the maximum flood discharge would not exceed 18,000 second feet, while Lake Manitoba may be manipulated as a storage lake so as to greatly increase the minimum flow.

The fall from Lake Manitoba consists of 13.2 feet in the Fairford and 86.5 feet in the Dauphin, which, in four separate sites, is capable of producing 28,860 h.-p. continuously.

THE WATERHEN RIVER

The Waterhen River joins Lake Winnipegosis to Lake Manitoba, and with the watershed of Lake Winnipegosis of 21,200 square miles and the head of 15 feet readily to be obtained between the two lakes at Meadow Portage, a valuable water power site exists, 6,800 h.-p. being estimated to be continually obtainable on the turbine shaft. To augment this, storage capacity of enormous proportions, when considered over the lake area of 2,000 square miles, is available.

On the Mossy River and the headwaters of Lake Dauphin, one of the tributaries of Lake Winnipegosis, several small sites recently investigated are suitable for power developments.

RED RIVER TRIBUTARIES

At present the power developments are in the tributaries only, the Little Saskatchewan River, which flows into the Assiniboine River in the South-western portion of the Province of Manitoba and thence into the Red River, having several developed sites.

The principal developments on the Little Saskatchewan are at Minnedosa and Brandon.

The Minnedosa plant consists of an earth dam 1,800 feet long, impounding a storage lake from which two wood stave pipes lead to the power house on a bend in the river located below the dam, 24 feet head being thus created. This plant has an installed capacity of 450 h.-p., with an ultimate capacity of 900 h.-p., and was built by the Minnedosa Power Company for local general distribution.

The power plant at Brandon is owned by the Brandon Electric Light Company. The development is located about one half mile above the junction of the Little Saskatchewan

St. Andrew's Dam, Red River, Manitoba.

with the Assiniboine. An earth dam, 450 feet long and 25 feet high, has been constructed, creating a power of about 600 kilowatts capacity at 33 feet head. This Company operates a steam plant, the exhaust of which is distributed and sold for heating purposes, so that in winter the hydro-electric plant is shut down and held in reserve as a standby to the steam plant.

The Assiniboine has but small concentrated drop available; at one point, however, twelve miles down stream from the City of Brandon, at Currie's Landing, a head of 15 feet may be created, which will be capable of producing for eight months of the year 1,369 h.-p., and at minimum flow 270 continuous horse-power, the commercial utilization of this power requiring a steam auxiliary plant.

While the Assiniboine has a drainage area of 59,550 square miles, this is principally composed of flat prairie country. On the Red River below Winnipeg a dam has been

constructed at St. Andrew's Rapids for river control. This dam does not create any power possibilities.

RIVERS OF THE EASTERN SHORE OF LAKE WINNIPEG

The Manigotagan and other rivers, lying north of this, flowing into Lake Winnipeg from the slopes of the eastern shore have power possibilities of more or less magnitude. The Manigotagan, the Bloodvein, the Pigeon, the Berens, the Poplar, The Big Black and the Belanger, have been subjects of more or less reconnaissance and investigation, and each will, as opportunities permit, be fully gauged and surveyed.

Wood Falls, Manigotagan River, Manitoba.

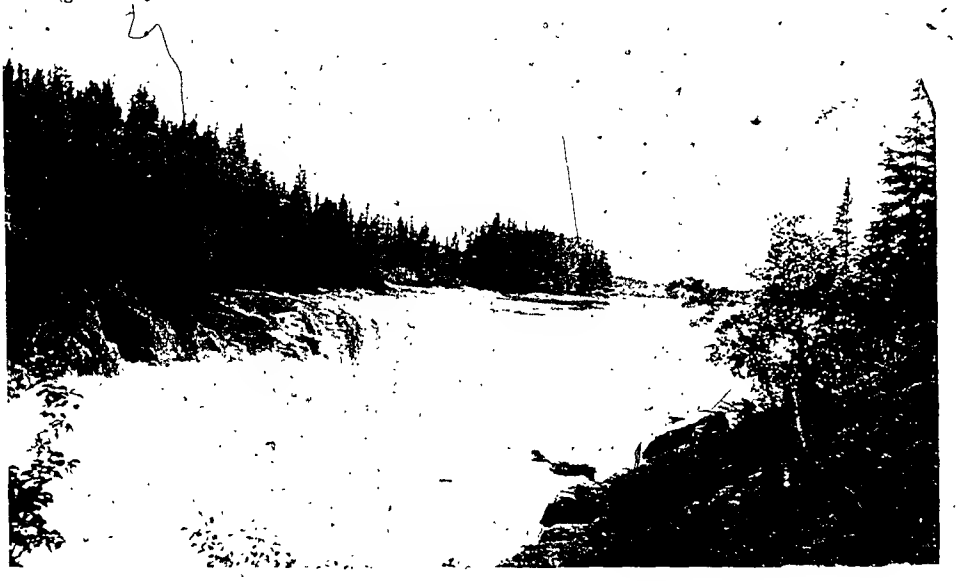
THE NELSON RIVER

The Nelson River, being the outlet of Lake Winnipeg, discharges the water collected by this lake from an immense drainage area. It is one of the principal drainage systems of the continent, having a tributary area of some 450,000 square miles.

The great expanse of Lake Winnipeg, and also of Lake Manitoba and Lake Winnipegosis, provides a regulation of river flow, maintaining but a small range between flood and minimum discharge. In this respect, the Nelson River is similar to the St. Lawrence, in that the flow of the latter has a natural regulation through the action of the Great Lakes.

The length of the Nelson River, from Lake Winnipeg to Hudson Bay, is 430 miles. In this distance a drop of some 700 feet occurs. In the upper reaches, the river could more properly be described as a chain of lakes connected by falls or by reaches of river and rapids.

In this upper portion of the river, extending approximately to Split Lake, some 250 miles from Lake Winnipeg, the banks are in general higher than found on the lower portion. Although the river, as stated, expands in this upper section into many lakes of practically ponded or of slow running water, yet the falls are more sharply defined and usually of steeper descent than found in the lower reaches, and at the same time are often separated by islands into numerous narrow channels. Not only are the banks lower as Lake Winnipeg is approached, but the distance between them becomes greater. The descent, also, is not so abrupt, being more often a series of rapids or swift running water. These latter characteristics gradually become more accentuated as Hudson Bay is approached.



Nelson River.

Expanding into Playgreen Lake, a short distance below Lake Winnipeg, the river flows from the former lake through two main branches, separated by Ross Island, and known as the East and West Rivers. The East River on which occurs Sea River Falls, is narrowed at many points by islands, although later it expands into Pipestone Lake. The West River is wider and is navigable by steamboat to Whiskey Jack Portage, which is in the vicinity of the junction of the two branches at Cross Lake. From this lake to Sipiwesk Lake, the river at first flows between islands, and drops through the Ebb and Flow Rapids, followed by the Whitemud Falls. The Bladder Rapids follow, in which the river flows in one narrow channel. Below this Rapids the river again divides into two main channels before Lake Sipiwesk is reached. On the Eastern channel three rapids are met with: Over-the-Hill, Red Rock and Chain of Rock Rapids. Below Sipiwesk Lake to the Manitou or Devil Rapids, the river is more contracted and retains this feature until it reaches Split Lake. In the reaches above this lake is Grand Rapids, followed by Chain-of-Island Rapids. Birthday or Overfall Rapids follows in the stretch of river to Gull Lake. Below this latter

lake, the river expands and is divided by islands with the formation of Gull, Kettle and Long Spruce Rapids. From Long Spruce Rapids to Hudson Bay, in which stretch the Limestone Rapids occur, the river is generally wider and free of islands.

On this great stretch of river will some day be located immense power developments. To-day the surveys of the Nelson from the power stand point are only being commenced. The water powers have been the subject of estimates of wide variance, but most conservatively the power possibilities will aggregate 2,500,000 h.-p., there being nineteen power sites that would produce from 77,150 to 235,500 h.-p. on the turbine shaft, on a basis of minimum flow of 50,000 cubic feet per second, a flow estimate even neglecting the regulation of the Winnipeg River, as is now proposed, to 20,000 cubic feet per second.

Many of the names, possibly in less than a generation hence, will be well-known in the list of Canadian water powers. They are listed as follows:

Possible Power Site	Heads	Estimated Horse Power based on minimum flow of 50,000 second feet at 80% efficiency.
	Feet	Horse Power
Whisky Jack Portage	40	181,150
Ebb and Flow Rapids	17	77,150
Whitemud Rapids	30	135,860
Bladder	20	90,575
Chain of Rocks Rapids	35	158,510
Devil's Rapids	25	113,220
Grand Rapids	27	122,530
Birthday Rapids	36	163,375
First Gull Rapids	17	77,150
Second " "	21	95,105
Third " "	20	90,575
Fourth " "	30	135,860
First Kettle "	17	77,150
Second " "	21 5	97,370
Third " "	40	181,150
Upper Long Sluice Rapids	40	181,150
Lower " " "	52	335,495
Upper Limestone Rapids	33	149,450
Lower " "	41	185,680
Total	562 5	2,548,505

The advent of the Hudson Bay Railway, now under construction, in a north-easterly direction from The Pas, in Manitoba, to Port Nelson on Hudson Bay eventually assumes a route paralleling the Nelson River, and thus promises to be a great factor in the power future of that river.

THE CHURCHILL RIVER

The Churchill River basin comprises the watershed lying immediately northward of the watershed of the Saskatchewan and Nelson Rivers, and flows into Hudson Bay. The watershed is 114,150 square miles in extent, the axis being practically east and west, extending westwards to the height of land dividing it from the Athabaska. Innumerable lakes of varying size occur throughout the whole basin, a characteristic quite different to that of the Saskatchewan to the south. In the southern portion of the drainage system, large areas of good agricultural clay are stated to be overlying the rock formation, but to the north the extent of the rock outcrop increases greatly. The river can for the most part be described more properly as a chain of lakes, and throughout its length many rapids and falls occur, with the exception of the portions near Hudson Bay, where for a distance of about 80 miles the river is comparatively free from formidable rapids.

As a power possibility the Churchill River offers a promising field for investigation. While no survey of this nature has as yet been made of either the portion of Manitoba or in the reaches outside the Province, it is known that considerable fall occurs throughout the extent of the river. Reindeer Lake, which is drained by Reindeer River, a tributary to the Churchill, some 60 miles west of the Manitoba boundary, is at an elevation of 1,150 feet above sea level, indicating a drop of that extent between the above mentioned lake and the mouth of the river. Ille a la Crosse, in the vicinity of the headwaters, is at an elevation of 1,330 feet, while Knee Lake, a considerable distance to the eastward, is 1,250 feet above sea level. Not only is there an indication of considerable fall on the river, but also the numerous and extensive lake areas indicate, not only great natural regulation of the flow, but also the possibility of further regulation through systems of storage on some of the larger lakes.

No discharge measurements have as yet been made on this river, nor is there anything definite known as to the precipitation. Assuming, however, a mean annual runoff of 0.3 second feet per square mile, this would give a mean annual discharge of some 34,000 second feet.

THE ATHABASKA RIVER

The Athabaska River is one of the largest rivers of the Province of Alberta, having its source on the eastern slope of the Rockies and a total drainage area of 39,000 square miles above Grand Rapids, which are about 160 miles below Athabaska Landing. Most of the tributaries join the main river in the mountains and foothills, the largest of these rivers being the Baptiste, McLeod, Pembina, Lesser Slave and La Biche, all of which join above Grand Rapids.

The upper part of the river flows through a very broken and rugged country which is for the most part well covered with timber. After leaving the foothills, the country is rolling

and well timbered and the river valley is very wide, a series of steps rising from the river whose banks are, generally, very low. The waters of the river average in slope about 2.5 feet to the mile, and there are no rapids to speak of above Grand Rapids, excepting a more than average swift at Pelican Rapids.

At Grand Rapids, where the river divides in two about an island, there is a drop of 50 feet, but the whole of this is not available for utilization, the upper portion only, or Big Grand Rapids, being the part that would be developed.

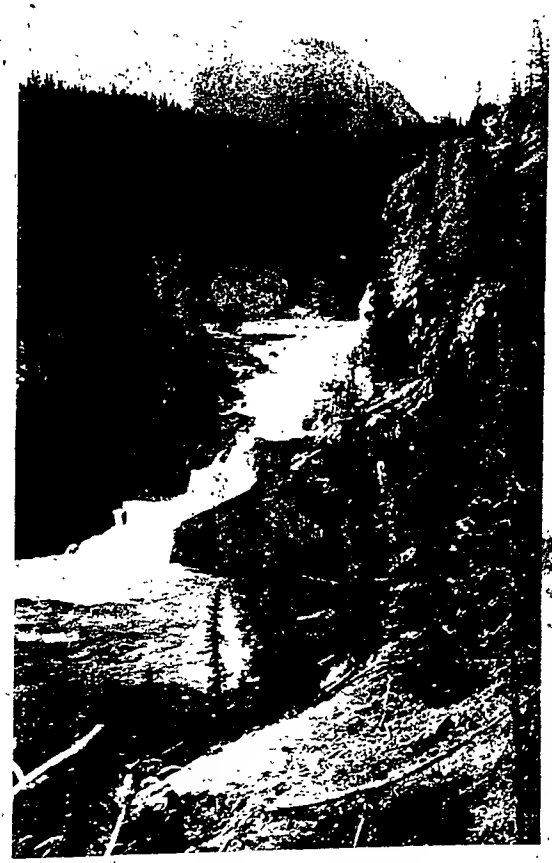
The measured water flows have been quite disappointing, the minimum flow being 2,368 cubic feet per second, while a maximum record was 61,621 cubic feet, and there were in addition evidences of a flood flow of 110,000 cubic feet per second. The low flow occurs in winter, and to offset this effect the Water Power Branch Engineers have sought for suitable storage sites available for the increase of the winter supply. After examination of those lakes, known to be of appreciable extent, including Jasper and Brule Lakes, Lac La Biche and Lesser Slave Lake, it was found that but small opportunity existed for the economical creation of storage.

With a flow of 2,300 cubic feet per second and the head of 45 feet obtainable at Grand Rapids, a turbine out-put of 9,410 h.-p. would be available, but at a construction cost of over $5,000,000 involving, as it does, a steam auxiliary plant and a transmission line of 200 miles in length to the City of Edmonton.

The market for power now exists at Edmonton, and the future of that City and its vicinity demands the establishment of a cheap power source of large dimensions.

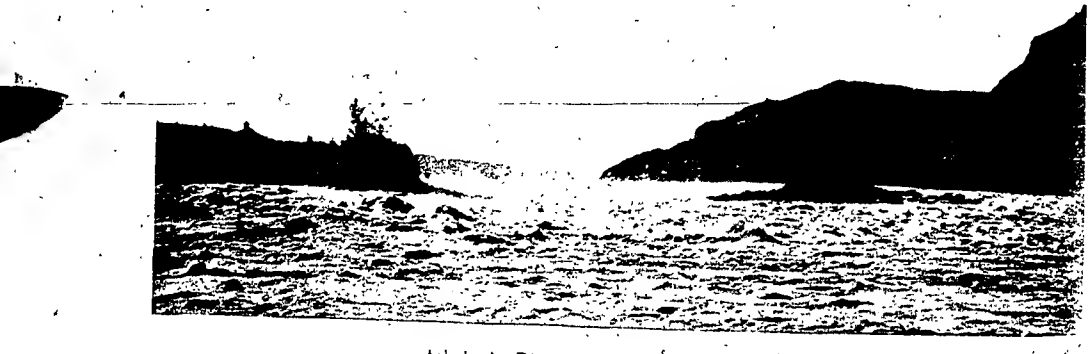
THE PEACE RIVER

The Peace River watershed is immediately to the north of the



Brazeau River, Alberta.

The Athabaska River.



Athabaska River. Grand Rapids from below.

Athabaska River, the Peace discharging into the Slave River immediately below Lake Athabaska, which lies at the foot of the Athabaska River. The Peace River has its head waters on the eastern slopes of the Rockies and to a great extent in the Province of British Columbia.

The Peace River country, with its 45,000,000 acres of arable land, just recently made accessible for settlement, is the "Last Great West" of Canada, and here will accumulate in time a population numbering in the millions.

Power is essential in such a district, and the many water powers said to exist, within the transmission zone, are now being investigated.

THE SLAVE RIVER

The Slave River drains Lake Athabaska into the Great Slave Lake, and between these there is a fall of 170 feet. There are some 16 miles of rapids in one stretch on this river which, when fully surveyed will, doubtless reveal an excellent water power site.

THE MACKENZIE RIVER

The Mackenzie River flows from the outlet of Great Slave Lake to Mackenzie Bay in the Arctic Ocean. With a watershed of 669,000 square miles and a drop of 520 feet in all, power possibilities should be available, but as there are no distinct waterfalls or large rapids a most careful investigation is necessary before any authorative statement can be made.

RESOURCES OF THE PROVINCES

AGRICULTURAL

THE greatest of the resources of the Prairie Provinces is the soil. The alluvial deposits of the ancient glacial lakes are responsible for the deep fertile silts and clay soils of the region, and after even twenty or twenty-five years of continual cropping with wheat the fertility in some districts has shown no signs of depreciation.

Probably there has never been a more striking instance of the power of agriculture to create a great and prosperous community than that which exists in the Prairies to-day. Forty years ago the population was numbered at not more than 12,000 people, a large proportion being Indians and half-breeds, while to-day a population of 1,500,000 people has been established, the numbers continuing to increase at an astounding pace.

Of the area of 479,162,438 acres of the three provinces, over 200,000,000 acres are arable, of which the acreage under crop was in 1913, 17,329,000 acres, a startling increase from the 3,491,413 acres under crop in 1900. From this land the 1913 value wheat, oats, barley and flax, amounted to $300,000,000.00. The future of this great resource certainly can be considered only in the most optimistic manner.

FORESTRY

Compared with other Provinces of the Dominion, the Prairie Provinces have not been considered as commercially rich in forest products. In 1912, the total tabled value of the timber cut in these provinces was over $4,000,000.00.

In Manitoba, spruce is the chief marketable wood, while poplar, tamarack, Jack pine, cedar, birch, oak, balsam, fir, elm and white and red pine are available, and each is comprised in the 1912 cut.

Saskatchewan is the chief producer of the three Provinces, the spruce cut of 1912 being valued at over $2,500,000.00, while tamarack, Jack pine and poplar, are also included in the total.

In Alberta, spruce leads in value, while Jack pine, poplar, Douglas fir, tamarack, birch and balsam fir, are also marketed.

In all the above spruce comprises about 90 per cent. of the total. Reforestation and prairie plantings of marketable woods are being carried on most satisfactorily.

Pulp woods abound in great quantities; the increasing use of newspaper, wrapping paper, etc., it is to be expected, will soon encourage the establishment of pulp and paper mills to supply the local requirements.

COAL

The coal deposits are particularly valuable. Alberta is the richest province in Canada in respect to coal areas, while Manitoba and Saskatchewan have quite extensive lignite deposits.

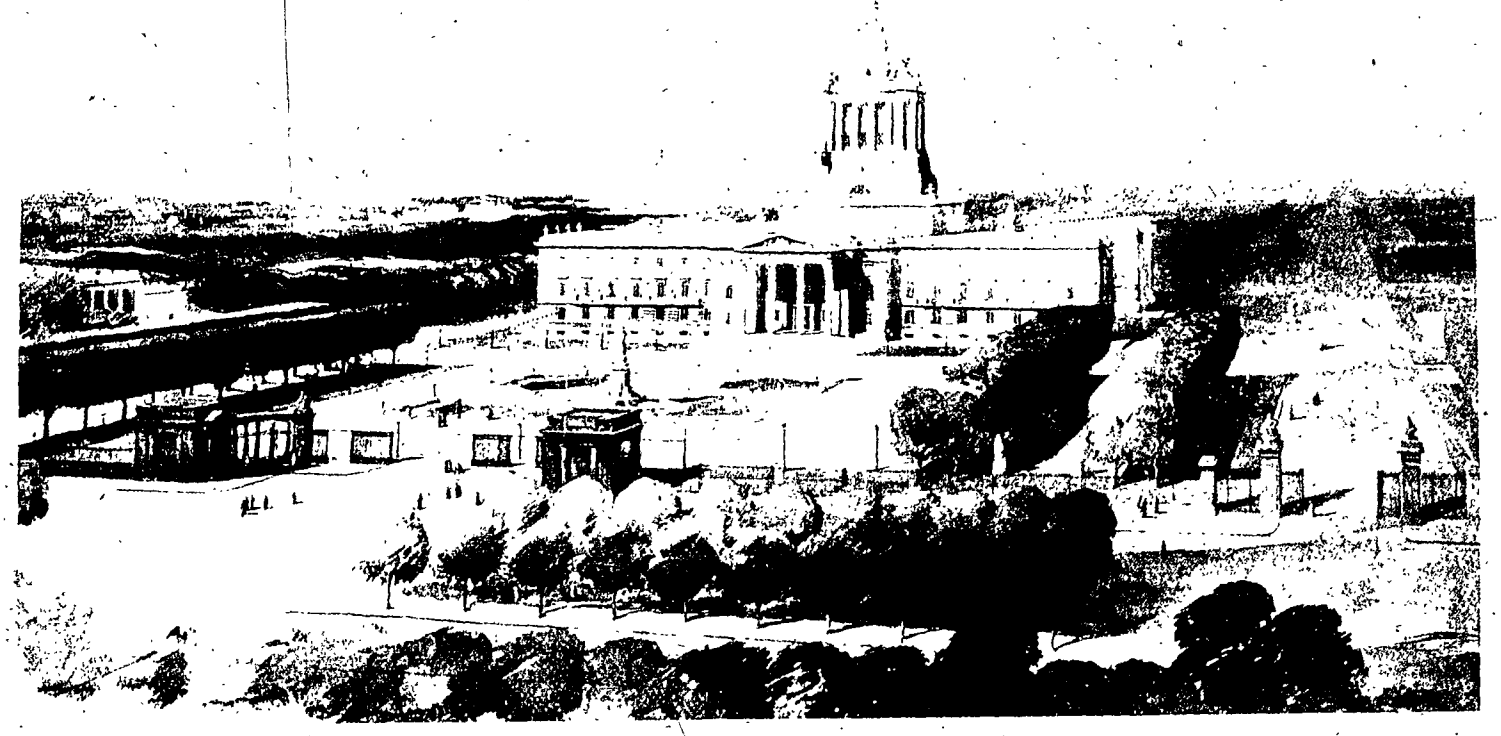
Alberta has a coal area of 19,582 square miles, in which it is estimated 400,000,000 tons of anthracite, 44,530,000,000 tons of bituminous and 60,000,000,000 tons of lignite exist, all of a wealth beyond imagination.

The western border of the southern part of Alberta consists of several ranges of mountains, formed generally of rocks, which were originally the floor on which the coal formations were laid down. These coals have been exposed in many localities, and form the well-known areas between the Crows Nest district and Banff, in the mountains and foothills.

The lignite of Alberta, known technically as the Edmonton coal, extends north from near the International boundary to near the Peace River, covering an area of at least 10,000 square miles. Another coal formation occupies the south-eastern portion of the Province, with an area of 5,000 square miles which, in the district surrounding Lethbridge, is of considerable value.

In Manitoba the coal bearing rocks occupy an area of about 48 square miles in the southern part underlying Turtle Mountain. The seams outcrop near the base of this hill, and it is estimated that 160,000,000 tons of lignite are available for mining.

In Saskatchewan the areas lie principally in the southern part and are being mined on the Souris River. The Coteau elevation is composed of coal bearing rocks which continue westward in the Wood Mountains and the Cypress hills. This area contains about 4,000 square miles, in which about 18,000,000,000 tons of lignite may be obtained.



Parliament Buildings, Manitoba from Drawing Construction.

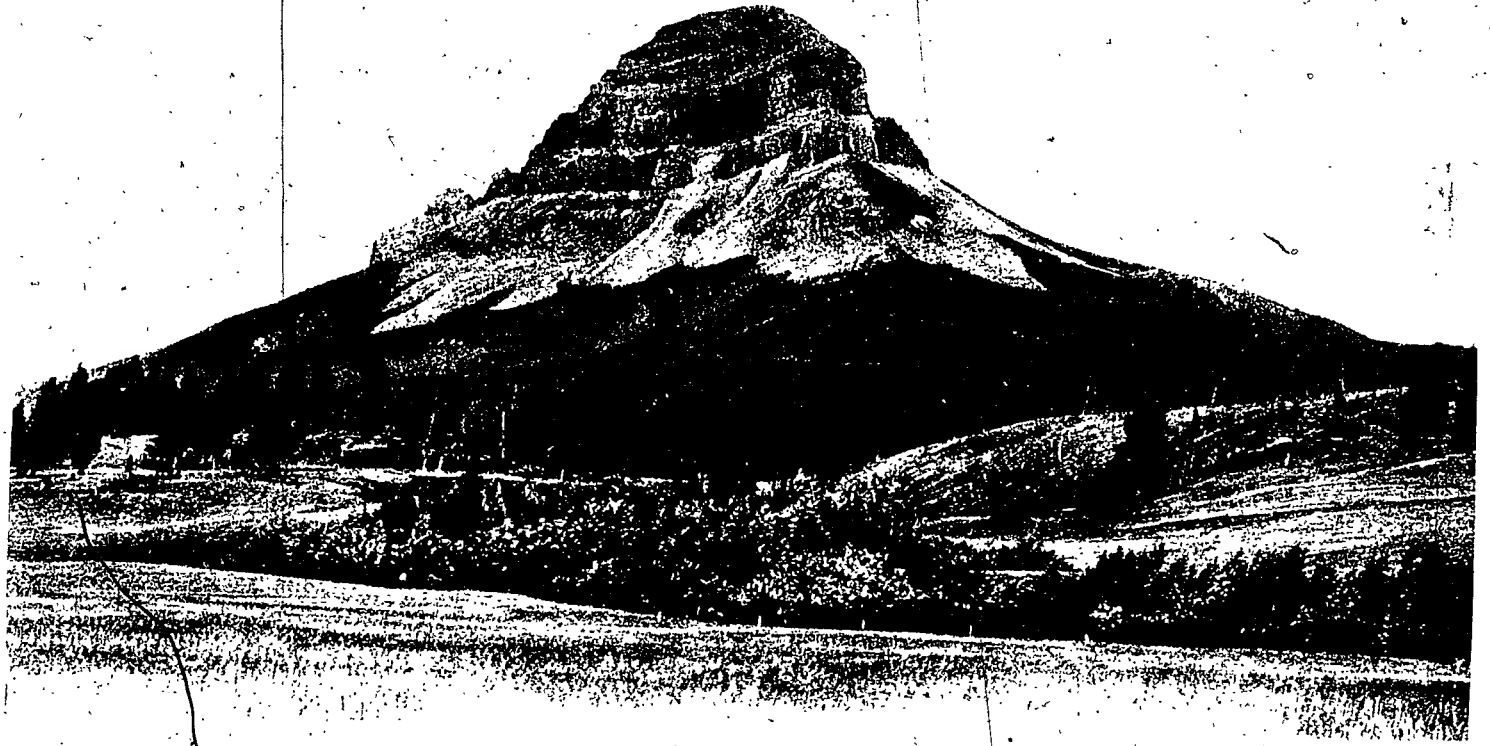
Saskatchewan Legislative Building, Regina

The coals of the mountains and foothills of Alberta are bituminous and anthracite of a very high grade; the Edmonton coal is a lignite of fair value, and that in the Lethbridge district is a good bituminous coal. The coals of Manitoba and Saskatchewan are lignite, of excellent calorific value, but now await an efficient method of utilization to become good commercial coals.

OIL AND GAS

In the Province of Alberta, in the vicinity of Calgary, some remarkable oil wells exist which, after the cessation of the usual financial flurry which the advent of such discoveries always creates, may seriously reveal a rich field. There is no doubt of the oil, but the extent and permanency is yet to be disclosed.

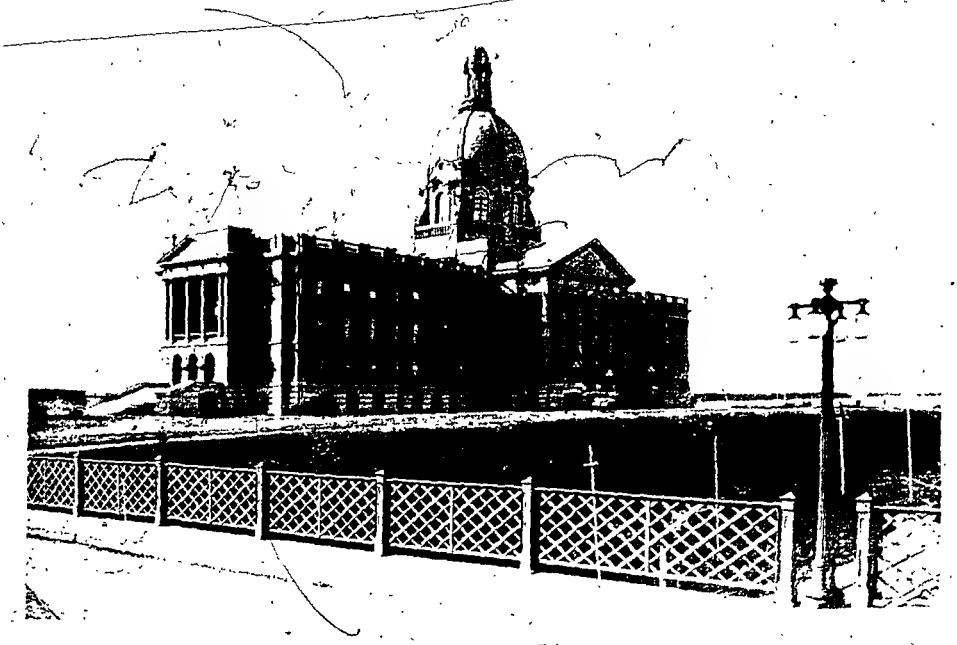
The gas district of Medicine Hat, in Alberta, is an extremely valuable resource, and this has already become the nucleus of extensive industries particularly of clay products, to which the use of natural gas is especially adapted.



The Crow's Nest Mountain, Crow's Nest Pass Railway.

PEAT

The peat bogs of the north are very extensive, the area, including the vast deposits of the Northwest Territories, being estimated at over 25,000 square miles. As a peat bog with an average depth of six feet, after drainage, contains 774,400 tons of air-dried peat per square mile, the vast resources of this material may be appreciated. The calorific value of such peat exceeds 8,000 British Thermal Units per pound, and while the difficulties in the utilization at present are mechanically not economic, the vast treasure must be looked upon as a prize for the inventive genius of the very near future, when it will assume no mean value.



Parliament Buildings, Edmonton.

BITUMEN

The tar sands of the McMurray district, in Northern Alberta, will, upon the completion of the projected railways northward, attain a commercial value. Many millions of tons exist, a great portion of which can readily be secured. These sands may become the source of the bitumen required for street paving, and for the numerous other uses which have recently been devised.

STONE, CEMENT AND CLAY PRODUCTS

All the provinces contain building stones of various qualities. Limestone, clay and shale are in abundance for Portland cement; calcareous shales suitable for natural cement;

gypsum, friable sandstone for glass; clay for the brick and tile industry, are all at present available, and over a wide area, are in commerce to-day.

GOLD

The gold deposits of the Prairie Provinces occur at various isolated places, no information as yet proving of any great extent. The neighboring provinces of British Columbia and Ontario and the Yukon are daily adding to their hundreds of millions of gold finds, and the discovering of an Eldorado may yet occur in the Eastern slopes of the Rockies, in the formations of the Eastern portions of Manitoba or in the great Northland.

IRON

Extensive outcroppings of iron occur in Lake Winnipeg, a mass of hematite being exposed at the "Narrows" on Black Island, near the outlet of the Bloodvein River. While for many years the water routes have carried the travellers through this district, prospecting on a comprehensive scale has not been attempted, but the commercial situation arising from the demand for steel and iron, the proximity of electric power for smelting and the excellent water transportation available to Winnipeg, have now justified the present interest being taken in the matter.

FURS

It would be unfair to the Northland and to the romantic history of the fur trade, not to mention furs as a natural resource of these Provinces. The enormous increase in the demand, and the prices obtainable, have greatly stimulated the activity of the industry.

IRRIGATION

Irrigation, as carried on in a portion of the West, must be considered in conjunction with water power. While irrigation may divert water from a river system and render more or less of such water unavailable again to the river supply, the necessary dams and retaining reservoirs provide valuable regulating effects usually more than offsetting any loss of water. Further, as the period of use of irrigation water, during spring and summer, corresponds to the usual period of flood flows and high water in the rivers, the water losses are usually negligible.

An area lying between Regina and Calgary, in Western Saskatchewan and Eastern Alberta, comprises a comparatively dry belt, a large portion of which may be readily irrigated.

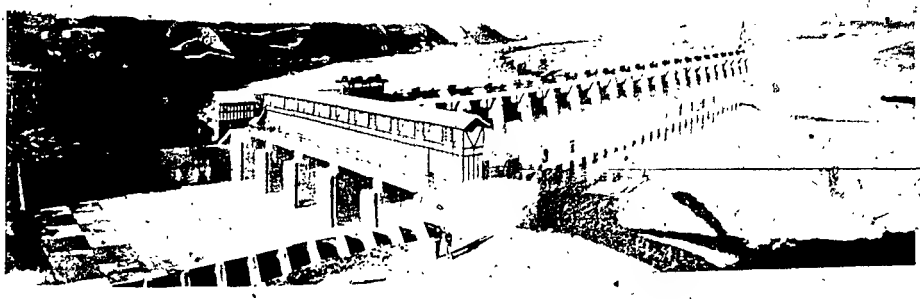
A great many irrigation systems exist, the largest being that of the Canadian Pacific Railway Company whose reservoir and headworks are on the Bow River, just below Calgary at Bassano. The Bassano dam is a notable engineering feat, whose magnitude may be readily appreciated by the reproduction on page 65. The area of the district, which may ultimately be included in this irrigation area, is some 3,000,000 acres, of which 363,000 acres is now served.

WATER POWER

Reverting to the subject of water powers it is apparent, by the previous chapters, that this natural resource has an enormous capitalized value, and that the future demands will ensure the complete development and regulation of all the water power rivers.

While it is apparent that, to-day, many portions of the prairies are not within the present economic zone of electrical transmission from the waterpowers on every side, yet the electrical art is still in its infancy. Electrical laws are known within limits, and apparatus and devices may appear to-day to be approaching the ultimate capabilities. Great strides will, however, yet be taken, and the distance intervening between water fall and market may not be always such a deciding factor in the development of a water power. To-day financial considerations, only, comprise the limits of transmission; any distance is feasible, electrically and mechanically. The water powers of to-day must not be considered for the next generation only; we are but leaving the bottom rung in the industrial ascent in Canada.

The immediate future, however, must be provided for. It is not economical to-day to deliver Winnipeg River power in Regina for instance, but in these central districts a great coal field exists; further west, and still remote from the water powers, natural gas is found. A trick of nature has covered the Prairie Provinces with power from water and from coal. By a more devious process, perhaps, and involving many different costs, the power of coal can be converted in a power station at the mine, and the electricity transmitted to its market as from the waterfall. The coal areas and the water power areas together well cover the Prairie Provinces, bringing practically all the communities and districts within their economic reach.



Bassano Dam on Bow River [illegible]

WATER POWER AND THE FUTURE

THE future of water power in the West requires no questioning as to its ultimate complete development. The new uses of electricity, bound to be evolved from time to time and quickly to be absorbed into the routine requirements of ordinary life, combined with the present rapidly growing power loads, will, within the period of one or two generations hence, demand the utilization of practically all the available water powers of the country.

To-day electricity maintains its commercial supremacy as a source of energy to the general public as a convenience; to the manufacturer, requiring a source of power, on account of its adaptability to his respective needs and by its economy in application; in the field of traction by its operative simplicity, cleanliness and comparative silence, and suitability to frequent short haul; and to the electrometallurgist and electrochemist by permitting of concentration of energy, simplification of processes and equipment, for its uniformity and control of results, and from its application in the production of materials unavailable from any other source. In communication and thereapeutics its field is absolute. Dominating all these elements of industrial power supremacy, cheapness of electrical energy is paramount.

In general a mixed power load consists of domestic, industrial or power load, municipal service, commercial lighting and street lighting. The domestic load has, by energetic campaigning by the power distributing companies, been constructed into one involving no mean figures; the former incandescent lighting load generally to be found in meagre quantities, even ten or fifteen years ago, has been greatly amplified, so that the unequipped and unlighted residence, anywhere throughout the Dominion within reach of electrical sources, has become the exception; the day load of the many household electrical accessories and conveniences has appreciably added to the consumed power tending to flatten out the peaked curve of this load, and extend the service hours of the distribution system and transformers over a longer remunerative period, and further get fuller advantage of power purchased on a peak load basis. The non-load night hours are now engaging the attention of the central station with the hopes of commercially establishing electric heating accumulators for charging during such hours. As yet it is the experience that lighting and domestic loads create a peak in early evening unapproached by any other loads on domestic service transformers.

For municipal uses, such as pumping and street lighting, electricity is universal, off-peak hour pumping into water reservoirs has proven an economical system when operated as a component of a mixed power load. The enormous strides in application and design of street lighting units, and the great efficiency to be obtained, has placed electrical street lighting far beyond the reach of any other illuminating source.

Electric power in industry has a wide and practically limitless field. As a motive power available in any capacity, conveniently and economically applicable in every class of service it out-ranks all its competitors from the rolling mill steam engine reversing its ponderous thousands of horse-power to the infinitesimal foot power of a sewing machine. In the he

ing and welding of materials as a part of the process of manufacture, electricity, by its control, speed and concentration or distribution, enjoys a peculiar field, distinct from either coal or gas.

Electric railways have not reached beyond the industrial, urban, interurban and terminal use. The electrification of trunk lines which awaits the supply of economic electric power at frequent intervals along the route, and the overcoming of the many necessary minor changes in trunk line operation, besides the enormous capital outlay required, comprise a combination of requirements not considered economically attractive as yet.

Electrometallurgy and electrochemistry have been responsible for the handling of materials not workable by any other means, have made available new materials and have greatly cheapened the production of many important materials of wide use. Aluminum, calcium carbide, chromium, cyanamid, silicon, etc., are products only from electrical processes. Alkalies, hypochlorite, phosphorous, magnesium, sodium, nitrates, etc., are produced at the lowest cost electrically.

In telephony and telegraphy; in radio-telephony and radio-telegraphy; in radiography and therapeutics; electricity, while possibly thus providing its greatest conveniences and aids afforded to mankind, is not involved in such power-consuming magnitude as to require further mention.

The near future will see the greatest progress in electro-chemical and electrometallurgical industry, in electrical trunk line transportation on the railways and in distribution of electricity in the rural districts.

As possibly affecting the West most vitally, the problem of chemically fertilizing of soil must demand serious attention. The great natural fertility of the prairie is dependent upon a wonderful but gradually exhausting store of plant foods, and the agriculturists have neglected the replenishing to maintain the original or necessary supply. In some parts of the West artificial fertilizing is a need of the present, and in the near future the demand will be universal. Nature replenishes the earth by the decaying of the plants which have absorbed the nourishment, by animal manures, by bacterial action and by the electrical discharges of the air.

Nitrogen is the greatest essential in the replenishing of soil; the atmosphere contains an unlimited supply, three quarters of the weight of the air being nitrogen, but in a form available for the soil. Above each square mile of land there is estimated to be 20,000,000 tons of nitrogen. As a result of electric action in the air, 100,000,000 tons of combined nitrogen are restored annually by nature to the soil of the planet, present in the form of nitric acid and nitrates in descending rain. By properly applied electrical discharges in the presence of air, this process can be duplicated, nitric acid and nitrates produced in commercial form. The locality of the manufacture of such a necessary commodity is, from the standpoint of transportation, nearest to the point of use, the distribution of the atmosphere is universal; in the Prairie Provinces the proximity of the great water powers adjacent to this coming market is most notable.

The 200,000,000 acres of arable land within the Provinces, when all placed under cultivation, will possibly consume on an average more than 100 pounds of nitrates to the acre

when intensive fertilization is resorted to. To-day the efficiency of electrical production of nitrates is low, but possibly five tons per horse-power year would be beyond the highest efficiency to be obtained in the future. The power required to meet such a yearly demand would have to be two million horse-power. The figures are staggering, but with time as an element and with Canadian wheat as a staple, in an ever widening market, such conditions must come to pass.

By electrometallurgy the iron ores of Lake Winnipeg will assume a commercial value, and the future market of the West for iron and steel will find considerable locally

The Water Prospector.

manufactured. Iron pigs and steel ingots from iron ore, produced by the electric furnace, are now an accomplished commercial fact.

Electrification of trunk line railways is a matter for time to bring about; conditions in the West, on the Prairies and in the Mountains, are ideal for this transformation.

Distribution of electricity in the rural districts may become a reality of the near future, while hydro-electric distribution has been studied in Manitoba on a very extensive scale, embracing the greater portion of the southerly part of the Province, the wide distribution necessary in supplying the remote rural districts, and the intermittent and comparatively small power demand now to be obtained does not at present justify its development. In the adjoining province of Ontario, however, a notable, publicly owned, system has been established, and besides transmitting power to towns and cities throughout a great area ov a network of over 2,000 miles of circuits, this system is now extending its lines so as to inclu

many of the rural districts, with the expectation that the load to be procured will eventually justify the extension to include the whole area traversed by the system.

It is not out of the way to predict that the Prairie Provinces will be served with transmission lines joining the Eastern, Northern and Western powers, augmented by steam driven plants at the coal mines and serving the transcontinental railways, the municipalities, the rural population, electro-chemical works, electrometallurgical works and wide spread industries, and that the power necessities even with the millions of horse-power now available in the rivers, in the near future will demand the greatest of conservation, regulation and efficiency of development at all these respective sites.

HOW TO ACQUIRE A LICENSE TO TAKE AND USE WATER FOR POWER PURPOSES

THE water powers in the Provinces of Manitoba, Saskatchewan and Alberta and in the North-West Territories, are administered under Water Power Regulations pursuant to the Dominion Lands Act. These regulations provide for limited grants, reasonable rental for the privileges granted, continuous control and periodic regulation of rates to consumers, best possible use of privilege and continuous beneficial operation, at the same time reasonable financial reward is assured the concessioneer.

Before an application can be considered by the Dominion Water Power Branch of the Department of the Interior, certain general engineering and technical data must be submitted by the applicant and of sufficient extent and scope to enable the Department to determine the main engineering and economic features of the proposal. The Department has the right to call for such further information as may be desired. If, upon consideration of the information furnished the Department, the engineering and economic features of the scheme are acceptable, the Minister may grant an agreement authorizing the proposed scheme which will provide for the following main features: the submission of detail working drawings and specifications within the first year of the agreement, the commencement of actual construction operations within one year of the formal approval by the Department of the detail working drawings and specifications; the expenditure on actual construction operations of a minimum amount to be determined by the Department, the development of a minimum amount of horse-power by a date to be set by the Minister and not to be longer than five years from the date of the agreement; all construction operations to be carried on under the continuous supervision of a Government Inspecting Engineer.

Upon the satisfactory completion of the terms of the agreement, a lease and a license are granted for a period of twenty-one years, renewable for three further periods; the license for the diversion and use of the water and the lease for the use of the necessary lands. They are concurrent and very largely co-terminus, providing in the main that the power must be continuously and beneficially operated; that the amount of power developed must be increased to sufficient capacity to meet the public requirements to the satisfaction of the Department.

The rates are under the continuous control of the Crown. The rental for the privileges granted is subject to revision at each twenty-one year renewal period. At the termination of the third renewal, compensation shall be paid for the works to an amount fixed by arbitration.

The Regulations briefly described above, and attached hereto, have been found to be very satisfactory from an administrative and a public utility point of view, and the public interest in developed and undeveloped water powers has been conserved.

REGULATIONS GOVERNING WATER POWER RIGHTS IN MANITOBA, SASKATCHEWAN, ALBERTA AND THE NORTH WEST TERRITORIES

Note. These regulations were made to apply to all Forest Reserves and Parks by order of His Excellency, the Governor-General in Council, dated June 6, 1911, and by order of His Royal Highness, the Governor-General in Council, dated August 2, 1913, in virtue of the provisions of Subsection (b) of Section 17 of the Dominion Forest Reserves and Parks Act.

Note.—These regulations were made to apply to all school lands by order of His Royal Highness, the Governor General in Council, dated the 9th of February, 1915.

Note.—By virtue of the provisions of the Railway Belt Water Act, 2 George V., Chapter 47, and the Railway Belt Water Act, 1913, 3-4 George V., Chapter 45, all water within the Railway Belt of British Columbia is administrated under and in accordance with the provisions of the Water Act, 1909, and amendments thereto, by the Province of British Columbia, except only the territory included within Dominion Parks.

WATER POWER REGULATIONS

UNDER THE DOMINION LANDS ACT AND THE DOMINION FOREST RESERVES AND PARKS ACT.

Regulations made by His Excellency the Governor-General in Council in virtue of the provisions of Subsection 2 of Section 35 of the Dominion Lands Act, 7-8 Edward VII., Chapter 20, and by His Royal Highness the Governor-General in Council in virtue of the provisions of Subsection (b) of Section 17 of the Dominion Forest Reserves and Parks Act, 1-2 George V., Chapter 10, to govern the granting and administration of water power rights in the Provinces of Manitoba, Saskatchewan, Alberta and in the North West Territories, and in Dominion Parks within the Railway Belt of British Columbia.

Section 35—DOMINION LANDS ACT—7-8 Edward VII., Chapter 20, as amended by Section 6, Chapter 27 of 4-5 George V.

35. Lands which are necessary for the protection of any water supply or lands upon which there is any water power, or which border upon or being close to a water power will be required or useful for the development and working of such water power, shall not be open to entry for homestead, for purchased homestead, or pre-emption, or be sold or conveyed in fee by the Crown, but may only be leased under regulations made by the Governor in Council.

2. Subject to rights which exist or may be created under the Irrigation Act, the Governor in Council may make regulations: (a) for the diversion, taking or use of water for power purposes, and the granting of the rights to divert, take and use water for such purposes, provided that it shall be a condition of the diversion or taking of water that it shall be returned to the channel through which it would have flowed if there had been no such diversion or taking, in such manner as not to lesson the volume of water in the said channel; (b) for the construction on or through Dominion or other lands of sluices, races, dams or other works necessary in connection with such diversion, taking or use of water; (c) for the transmission, distribution, sale and use of power and energy generated therefrom; (d) for the damming of and diversion of any stream, watercourse, lake or other body of water for the purpose of storing water to augment or increase the flow of water for power purposes during dry season; (e) for fixing the fees, charges, rents, royalties or dues to be paid for the use of water for power purposes, and the rates to be charged for power or energy derived therefrom.

3. Any person who under such regulations is authorized to divert, take or use water for power purposes, or to construct works in connection with the diversion, taking or use of water for such purposes, shall for the purposes of his undertaking have the powers conferred by the Railway Act upon the railway companies, including those for the acquisition and taking of the requisite lands, so far as such powers are applicable to the undertaking and are not inconsistent with the provisions of this Act or the regulations thereunder, or with the authority given to such persons under such regulations; the provisions of the said Railway Act giving such powers being taken for the purposes of this section to refer to the undertaking of such person where in that Act they refer to the railway of the railway company concerned.

4. All maps, plans and books of reference showing lands other than Crown lands necessary to be acquired by any such person for right of way or other purposes in connection with his undertaking, shall be signed and certified correct by a duly qualified Dominion Land Surveyor.

5. Such maps, plans and books of reference shall be prepared in duplicate, and one copy thereof shall be filed in the office of the Minister at Ottawa, and the other shall be registered in the land titles office for the registration district within which the lands affected are situated.

6. The Minister, or such officer as he designates, shall in case of dispute, be the sole and final judge as to the area of land which may be taken by any person without the consent of the owner for any purpose in connection with any water power undertaking

REGULATIONS

Governing the granting of water power rights in the Provinces of Manitoba, Saskatchewan and Alberta, and in the North West Territories, including all Dominion Forest Reserves and Parks, and in Dominion Parks within the Railway Belt of British Columbia.

Established and approved by orders of His Excellency, the Governor-General in Council, dated June 2, 1909, June 8, 1909, April 20, 1910, January 24, 1911, August 12, 1911, and by orders of His Royal Highness, the Governor-General in Council, dated August 2, 1913, and February 9, 1915, in virtue of the provisions of Subsection 2 of Section 35 of the Dominion Lands Act, 7-8 Edward VII., Chapter 20.

Definition of Works

1. Under these regulations the word "works" shall be held to mean and include all sluices, races, dams, weirs, tunnels, pits, slides, flumes, machine fixed to the soil, buildings and other structures for taking, diverting and storing water for power purposes, or for developing water power and rendering the same available for use.

Mode of Application

2. Every applicant for a license to take and use water for power purposes shall file with the Minister of the Interior a statement in duplicate setting forth:

(a) The name, address and occupation of the applicant.

(b) The financial standing of the applicant so far as it relates to his ability to carry out the proposed works.

(c) The character of the proposed works.

(d) The name, or if unnamed, a sufficient description of the river, lake or other source from which water is proposed to be taken or diverted.

(e) The point of diversion.

(f) The height of the fall or rapid of such river, lake or other source of water at high, medium and low stages, with corresponding discharge of water per second, reckoned approximately in cubic feet.

(g) A reasonably accurate description, and the area, of the lands required in connection with the proposed works, such lands, if in surveyed territory, to be described by section, township and range, or river or other lot, as the case may be, and a statement whether such lands are or are not Dominion lands.

(h) If such lands are not Dominion lands, then the applicant shall give the name of the registered owner in fee, and of any registered mortgagee or lessee thereof, and of any claimant in actual possession other than a registered owner, mortgagee or lessee.

(i) The minimum and maximum amount of water power which the applicant proposes to develop, and the maximum amount of water which he desires for such purpose.
(j) Sketch plan showing approximate locations of the proposed works.
(k) Elevations of head water and tail water of the nearest existing works, if any, below and above the proposed works.
(l) Particulars as to any water to be taken, diverted or stored to the detriment of the operation of existing works, if any.
(m) Particulars as to any irrigation ditches or reservoirs, or other works for irrigation within the meaning of The Irrigation Act, in use or in course of construction within the vicinity of the proposed works, and which might affect or be affected by the operation of the proposed works.

Application by a Company

3. If the applicant be an incorporated company, the statement shall, in addition to the foregoing information, set forth,

(a) The name of the company.
(b) The names of the directors and officers of the company and their places of residence.
(c) The head office of the company in Canada.
(d) The amount of subscribed and paid-up capital, and the proposed method of raising further funds, if required, for the construction and operation of the proposed works.
(e) Copy of such parts of the charter or memorandum of association as authorize the application and proposed works.

Application by a Municipality

4. If the applicant be a municipality, then, excluding the special [illegible] given by a company, the following information shall be given:

(a) The location, area and boundaries of the municipality.
(b) The approximate number of its inhabitants.
(c) The present estimated value of the property [illegible] such municipality, and the value of the property subject to taxation [illegible] such municipality.

Minister may request further information

5. The Minister of the Interior shall have the power to call for such other plans and descriptions, together with such measurements, specifications, levels, profiles, elevations and other information as he may deem necessary, and the same shall be furnished by and at the expense of the applicant.

The Agreement for,—(a) A license for the diversion and use of water.
(b) A lease of the necessary lands.

6. Upon receipt and consideration of the application, and information accompanying same, the Minister of the Interior may, if he approves of the proposed works, enter into an agreement with the applicant, which agreement, in addition to usual conditions and covenants, shall contain clauses to provide as follows:

(a) For a time within which the proposed works shall be begun.

(b) For a stated minimum amount of expenditure to be made in connection with the works annually during the term of the agreement.

(c) For a stated amount of water power to be developed from the water applied for within a fixed period not exceeding five years.

(d) For summary cancellation of the agreement by the Minister if any of the above conditions have not been complied with.

(e) For defining and allotting the areas of Dominion lands within which the applicant may construct and operate the proposed works; and if there be no Dominion lands available for such purpose then for defining and allotting the lands in regard to which the applicant may exercise the powers given under section 35, subsection 3 of the Dominion Lands Act.

(f) For granting a license to the applicant, upon fulfilment of the said agreement, to take, divert and use for power purposes a stated maximum amount of water, in accordance with the application, and plans and specifications as approved by the Minister; the term of such license to be twenty-one years at a fixed fee payable annually, and such license to be renewable as provided for in these regulations.

(g) For granting a lease to the applicant of such Dominion lands as may be allotted under paragraph (e) of this section, and approved of by the Minister, such lease to be at a fixed rental, for a term of twenty-one years running concurrently with the said license, and renewable in like manner, and as near as may be subject to all the terms and conditions thereof. When there are no Dominion lands available for such purpose, or when other lands are considered by the Minister to be more suitable for such purpose, then the Minister shall define such lands in regard to which the applicant may exercise the powers given under section 35, subsection 3, of the Dominion Lands Act.

Inspection of Construction Work

7. During the construction of any works for the development of water power the Minister of the Interior, or any engineer appointed by him for that purpose, shall have free access to all parts of such works for the purpose of inspecting same, and ascertaining if the construction thereof is in accordance with the plans and specifications approved of by the Minister, and whether the terms of the agreement, as provided for in the preceding section, are being fulfilled.

The License for the Diversion and Use of Water

1. Upon the fulfilment by the applicant of the conditions of the said agreement, the Minister of the Interior shall grant to the applicant a license as agreed upon, and such license shall contain clauses to provide as follows:

(a) The term of the license shall be twenty-one years, renewable for three further consecutive terms of twenty-one years each, at a fixed fee payable annually and to be readjusted at the beginning of each term, as hereunder provided.

(b) At the expiry of each term of twenty-one years the Governor in Council, may, on the recommendation of the Minister, order and direct that the license and any lease granted in connection therewith be cancelled: *Provided* that the Minister shall have given at least one year's notice to the licensee of intention so to cancel.

(c) If the licensee shall refuse to pay the license fee as readjusted by the Governor in Council, or as fixed by arbitrators chosen as provided in paragraph (e) hereunder, then in such case the Minister may renew the license at the former fee, or the Governor in Council may, on the recommendation of the Minister, order and direct that the license and any lease issued in connection therewith be cancelled.

(d) In either of the above cases compensation shall be paid to the licensee as provided for in paragraph (e) hereunder.

(e) On termination of the third renewal of such license, except in case of default on the part of the licensee in observance of any of the conditions thereof, or of any lease granted in connection therewith, compensation shall be paid for the works to the amount fixed by arbitration, one arbitrator to be appointed by the Governor in Council, the second by the licensee, and the third by the two so appointed. If the licensee fails to appoint an arbitrator within ten days after being notified by the Minister to make such appointment, or if the two arbitrators appointed by the Governor General in Council and the licensee fail to agree upon the third arbitrator within ten days after their appointment or within such further period as may be fixed by the Minister in either such cases such arbitrator or the third arbitrator, as the case may be, shall be appointed by the judge of the Exchequer Court of Canada. In fixing the amount of compensation only the value of the actual and tangible works and of any lands held in fee in connection therewith shall be considered, and not the value of the rights and privileges granted or the revenues, profits or dividends, being or likely to be derived therefrom.

(f) The license shall state the maximum amount of water which the licensee may divert, store and use for power purposes, and shall provide for the return to the stream, or other source of water, of the full amount so diverted.

(g) The licensee shall develop such power as, in the opinion of the Minister, there shall be a public demand for, up to the full extent possible from the amount of water granted by the license.

(h) Upon a report being made by the Minister of the Interior to the Governor in Council that the licensee has not developed the amount of power for which there is a public demand, and which could be developed from the amount of water granted by the license, the Governor in Council may order to be developed and rendered available for public use the additional amount of power for which there is, in the opinion of the Minister a public demand, up to the full extent possible from the amount of water granted by the license, and within a period to be fixed by the Minister, which period shall not be less than two years after the licensee or person in charge of the existing works shall have been notified of such order, and in default of compliance with such order the Governor in Council may direct that the license, together with any lease issued under these regulations shall be cancelled, and the works shall thereupon vest and become the property of the Crown without any compensation to the licensee.

(i) Upon a report being made by the Minister of the Interior to the Governor in Council that a greater amount of water power could be developed advantageously to the public interests from the same stream or other source of water from which the existing works derive power and (1st) that the existing works could be enlarged or added to for such purpose; then the Governor in Council may authorize the Minister to offer the licensee the privilege of constructing and operating such enlarged or additional works at or in the vicinity of the existing works, and to grant such supplementary license as he may consider proper for such purpose, and if the licensee fail within six months thereafter to accept such offer, and in good faith to begin and carry on to completion such enlarged and additional works, and to complete same in accordance with plans and specifications approved of by the Minister, and within a fixed period not to exceed five years, and upon like conditions as the existing works were begun and completed; or (2nd) if the Minister shall report to the Governor in Council that the existing works, owing to their location or construction, cannot advantageously be enlarged or added to in order to develop further power sufficient to meet the probable demand, or would be a hindrance to other works contemplated for such purpose; or (3rd) that the existing works cannot, or will not, be any longer advantageously operated owing to the exercise of rights existing or created under the Irrigation Act; then in every such case, the Governor in Council may order and direct that the license, and any lease in connection therewith, and all rights thereunder, shall be cancelled, and the existing works shall thereupon vest in and become the property of the Crown: Provided always that in every such case compensation shall be paid to the licensee as provided for in paragraph (e) of section 8 of these regulations, together with a bonus apportioned as follows:

(1) If the works have been in operation less than five years, a thirty per cent. bonus upon the value of the works.

(2) If in operation more than five years, and less than ten years, a twenty-five per cent. bonus.

(3) If in operation more than ten, and less than fifteen years, a twenty per cent. bonus.

(4) If in operation more than fifteen, and less than twenty years, a fifteen per cent. bonus.

(5) If in operation twenty years or more, a ten per cent. bonus

(j) That the license shall not be transferable without the written consent of the Minister, and that if the licensee fail to keep and observe all or any of the conditions of the license, or any renewal thereof, or of any lease to be issued in connection therewith, then the license, together with such lease, shall in every such case be subject to cancellation by the Exchequer Court in the application of the Crown.

(k) That a schedule of rates and prices to be charged to the public for the use of power shall first be submitted by the licensee to the Board of Railway Commissioners of Canada for adjustment and approval before being put into effect, and that no rates or prices for power shall be legal or enforceable until such schedule has been so adjusted and approved nor if they shall exceed the amount fixed by such schedule; and that such schedule shall be readjusted and approved by the Board every seven years during the term of the lease and license, and all renewals thereof.

(l) That for the purpose of ascertaining the quantity of power actually developed, or capable of being developed, from the amount of water granted by such license, the Minister, or any engineer appointed by him for that purpose, shall have free access to all parts of the works, and to all books, plans or records in connection therewith, bearing on the quantity of power developed, and may make measurements, take observations and do such other things as he may consider necessary or expedient for such purpose, and the findings of the Minister, or such engineer, thereon shall be conclusive and binding upon the licensee

(m) For the proper provision, as required by law, for the passage of logs and timber down the stream or other waterway affected by the works.

(n) For the erection and maintenance by the licensee of a durable and efficient fishway in the stream or other waterway affected by the works when so required by the proper officer or authority in that behalf.

(o) That the licensee shall have no right to any water beyond the amount stated in the license.

(p) For the indemnifying of the Crown against all actions, claims or demands against it by reason of anything done by the licensee in the exercise or purported exercise of the rights and privileges granted under the lease or license.

Form of Agreements and Licenses

9. The agreements and licenses to be issued hereunder shall, subject always to the provisions of these regulations, be in such form and contain such provisions as the Minister may from time to time determine.

Storage of Water

10. If at any time it is proposed by the applicant or the licensee to divert water from any lake or body of water for storage purposes, or to dam same in order to augment the flow of water in any stream from which water power is to be developed, the applicant or licensee shall, in addition to other information required under these regulations, file plans as follows:

(a) A general plan in duplicate, on tracing linen, showing the location of such lake or other body of water, and the lands to be submerged or otherwise affected, and contour lines showing the water level at high and low stages, and the level to which it is proposed to raise such water for storage, and the estimated storage capacity of such lake or other body of water.

(b) A plan in duplicate from actual survey, by a Dominion Land Surveyor, and certified to by him, showing the lands to be submerged or otherwise affected by the proposed storage; the name of the registered owner in fee of such lands, and of any registered mortgagee or lessee thereof, and of any claimant in actual possession other than a registered owner, mortgagee or lessee.

(c) A detail plan in duplicate on tracing linen, showing all dams and other works proposed to be constructed in connection with such storage.

Form of Authority of Storage of Water

11. When the plans for such storage of water have been approved of by the Minister of the Interior, provision for same shall be made in the agreement for a license, or in the license itself, or in a supplementary license to be issued for such purpose, upon such terms and conditions as may appear to the Minister reasonable or expedient in the circumstances of each case, and subject to these regulations.

Small Water Powers of less Capacity than 200 horse-power

12. If upon receipt and consideration of the information set out in sections 2, 3, 4 and 5, the water power to be developed is found to have no greater capacity than 200 horse-power at the average low stage of water, the Minister may issue a lease and a license as may be required, authorizing the development of the proposed power; the lease and license to be for a period of ten years, subject to such special terms and conditions as may be considered advisable in each particular case and renewable if in the opinion of the Minister the power has been continuously and beneficially used.

For further information regarding water powers in Canada, application should be made direct to the following administrative officers of the Dominion and the various Provincial Governments:

Province of British Columbia: The Comptroller of Water Rights, Victoria, B.C.

Provinces of Manitoba, Saskatchewan and Alberta: The Superintendent of Dominion Water Power Branch, Ottawa, Ont.

Province of Ontario: The Deputy Minister of Lands, Forests and Mines, Toronto, Ont; also, to the Secretary of the Hydro-Electric Power Commission of Ontario, Toronto, Ont.

Province of Quebec: The Chief Engineer, Hydraulic Service, Department of Lands and Forests, Quebec, Que.

Province of New Brunswick: Surveyor-General of New Brunswick, Fredericton, N.B.

Province of Nova Scotia: The Secretary of the Nova Scotia Water Power Commission, Halifax N.S.